

U.S. Department of Transportation

Federal Highway Administration

December 1997

Pavement Recycling Guidelines for State and Local Governments





Participant's Notebook

2-DAY WORKSHOP COURSE ON PAVEMENT RECYCLING

Session	Chapter	Topic	No. of Slides	Start Time	Find Time	Alloted Time (Hours)
DAY ON	E					
		Introduction		1:00 pm	1:15 pm	1/4
1	1	Introduction to Pavement Recycling	27	1:15 pm	2:00 pm	3/4 (5 min discussion at end)
2	2	Performance of Recycled Mixes	39	2:00 pm	5: 10 pm	1 (5 min discussion at end)
		BREAK		3:00 pm	3:15 pm	1/4
3	3	Selection of Pavement for Recycling and Recycling Strategies	51	3:15 pm	4:45 pm	1½ (15 min discussion & some discussion during presentation)
4.	4	Economics of Recycling	27	4:45 pm	5:30 pm	3/4 (15 min discussion)
DAY TW	/O		<u> </u>			
5	5	Hot Mix Asphalt Recycling (Batch Plant) (Construction Methods and Equipment)	58	8:00 am	9:30 am	11/2 (5 min discussion)
6	6	Hot Mix Recycling (Drum Plant) (Construction Methods and Equipment)	31	9:30 am	10:30 am	1 (15 min discussion)
		BREAK		10:30 am	10:45 am	1/4
7	8	Hot Mix Asphalt Recycling (Case Histories & QC/QA)	38	10:45 am	11:45 am	1 (5 min discussion)
		LUNCH		11:45 am	12:45 pm	1
8	9	Hot In-Place Recycling (Construction Methods & Equipment)	45	12:45 pm	2:00 pm	11/4 (5 min discussion)
9	11	Hot In-Place Recycling (Case Histories & QC/QA)	46	2:00 pm	3:15 pm	11/4 (5 min discussion)
		BREAK		3:15 pm	3:30 pm	1/4
10	12	Cold Mix Asphalt Recycling (Central Plant) (Construction Methods & Equipment)	27	3:30 pm	4:15 pm	3/4 (5 min discussion)
11	13	Cold Mix Asphalt Recycling (In- Place) (Construction Methods & Equipment)	37	4:15 pm	5:15 pm	1 (5 min discussion)
DAY TH	REE					
12	15	Cold-Mix Asphalt Recycling (Case Histories & QC/QA)	57	8:00 am	9:30 am	1½ (5 min discussion)
13	16	Full Depth Reclamation (Construction Methods & Equipment)	39	9:30 am	10:30 am	1 (5 min discussion)
		BREAK		10:30 am	10:45 am	1/4
14	17	Full Depth Reclamation (Case Histories and QC/QA)	40	10:45 am	11:45 am	1 (5 min discussion)
-	-	General Discussion		11:45 am	12:00 pm	1/4

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Introduction to Asphalt Pavement Recycling

Slide 2

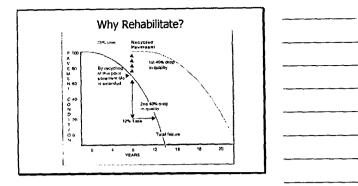
Advantages

- Reduced Cost of Construction
- Conservation of Aggregate and Binders
- Preservation of Existing Pavement Geometrics
- Preservation of Environment
- Conservation of Energy
- Less User Delay

Slide 3

Recycling is One of the Various Rehabilitation Alternatives

Slide 4



Why Rehabilitate?

- Inadequate Ride Quality
- Excessive Pavement Distress
- Reduced Surface Friction

Slide 6

Why Rehabilitate? (Continued)

- Excessive Maintenance Requirement
- Unacceptable User Costs
- Inadequate Structural Capacity for Planned Use or Projected Traffic Volumes

Slide 7		
No.	Recycling Methods	
	■ Hot Mix Recycling	
	■ Hot In-Place Recycling	
	■ Cold In-Place Recycling	
Manage	■ Full Depth Reclamation	
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Same and Assessing	RAP	
	Reclaimed Asphalt Pavement	
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Slide 9		
	Hot Mix Recycling: Process	and the second of the second o
	■ RAP is Combined with New Aggregate and	
	Asphalt Binder or Recycling Agent in a Hot Mix Plant. Mix is Transported to Paving Site,	
	Placed, and Compacted.	
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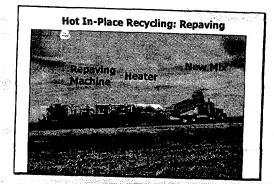
Hot In-Place Recycling: Process

■ Existing Asphalt Surface is Heated, Scarified to a Depth from 20 to 40 mm, Scarified Material Combined with Aggregate and/or Asphalt Binder and/or Recycling Agent and Compacted. New Overlay may or may not be Provided.

Slide 12



Slide 13



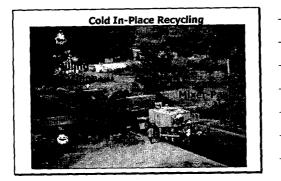
Slide 14



Cold In-Place Recycling: Process

■ Existing Asphalt Pavement Milled (75 to 100 mm Depth), RAP Reduced if Needed, Mixed with Recycling Agent, Placed, and Compacted.

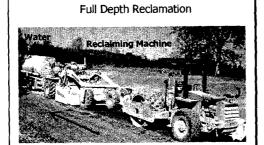
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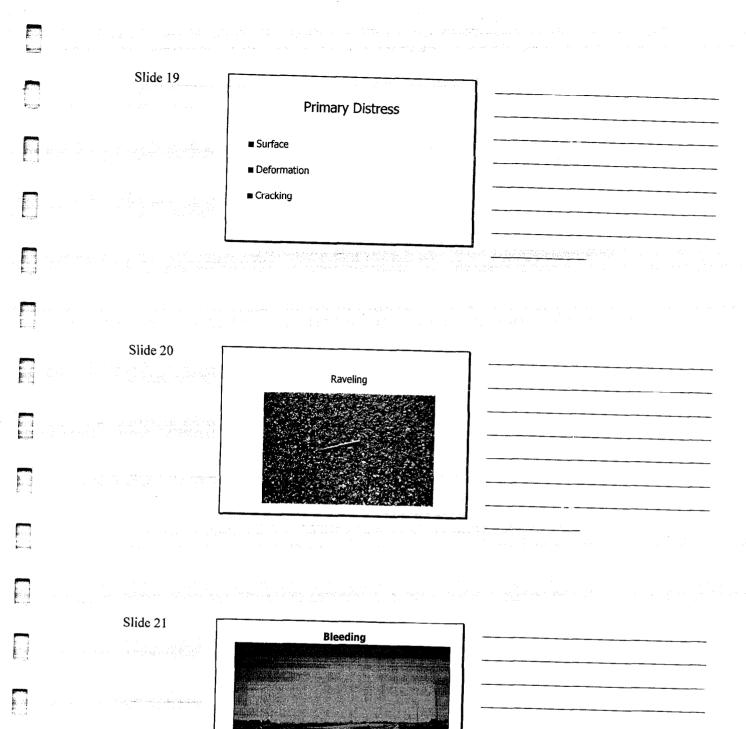


Full Depth Reclamation: Process

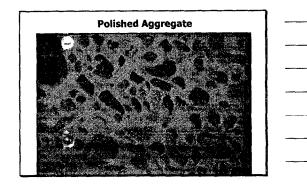
All HMA Layers and Predetermined Thickness of Underlying Material Pulverized, Stabilized with Additives, Shaped, and Compacted. A Surface Course is Applied.

Slide 18

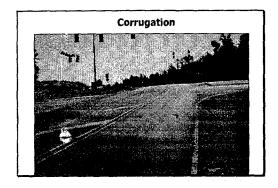




Slide 22



Slide 23



Slide 24



Slide 25	Thermal Cracking	
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Summary

Recycling Techniques are Available to Address Specific Pavement Distress and/or Pavement Structural Requirement

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Introduction to Asphalt Pavement Recycling

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		Performance Data of	
		Recycled Mixtures	
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	e 2	Performance Data of Recycled Mixtures Hot Mix Asphalt Recycling Hot In-Place Recycling (HIR)	
	e 2	Performance Data of Recycled Mixtures Hot Mix Asphalt Recycling Hot In-Place Recycling (HIR) Cold Mix and Cold In-Place Recycling	
	e 2	Performance Data of Recycled Mixtures Hot Mix Asphalt Recycling Hot In-Place Recycling (HIR) Cold Mix and Cold In-Place Recycling Full Depth Reclamation	

Performance Data of Recycled Mixtures

- Hot Mix Asphalt Recycling
- Hot In-Place Recycling (HIR)
- Cold Mix and Cold In-Place Recycling
- Full Depth Reclamation

Slide 4	1	
	Hot Mix Asphalt Recycling	
	- Head Routingly No Longor	
	■ Used Routinely, No Longer Experimental	
	■ Has Performed as Good as Conventional	
	Pavements	
Slide 5	Florida	
	■ Milling and Hot Mix Recycling Standard	
	Process	
	■ Reflective Cracks Removed	
	■ Comprehensive Specification, Sampling	
	and Testing Program	
	■ Recycled Binder Tested During Production	
61:3- 6		7
Slide 6	Georgia	
	■ Comparative Evaluation of 5 Projects Containing Recycled and Control	
	Wearing Course	
	■ RAP 25% (Range: 10% - 40%)	
	■ No Significant Rutting, Raveling and Fatigue Cracking	
	■ Cores Obtained for Testing	

Make System		
Slide 7	Louisiana	
	■ 10 Recycled Pavements Evaluated after	
	6-9 Years in Service	
	■ No Significant Difference Between Recycled and Control Sections in terms	
	of	
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	Performance Data of Recycled Mixtures	
	■ Hot Mix Asphalt Recycling	
A Basilian Communication of the Communication of th	■ Hot In-Place Recycling (HIR)	
The second of the second of the second	■ C^ld Mix and Cold In-Place Recycling	
Property (1997)	■ Full Depth Reclamation	
Records to the second s		
Slide 9		
	Hot In-Place Recycling (HIR)	
	■ Performance Generally Satisfactory	
Section 1	■ Equipment Improved Significantly During Last Several Years	
	■ Poor Performance of Some Projects - Bad Candidates for HIR	

Canada

- 10 HIR Projects Evaluated in Alberta
- 50 mm HIR One Pass of Recycling
- Visual Condition Survey
 Reflective Cracks Only
 Rut Depth 3-7 mm
- Field Cores
 No Significant Aging of Binder in 6
 Years

Slide 11





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■ Reported in TRB Synthesis No. 193 (1994)	
■ 22 States	
■ Excellent To Good Performance	
Assignable Cause For Fair to Poor Performance	
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Performance Data of Recycled Mixtures	
■ Fiot Mix Asphalt Recycling	
■ Hot In-Place Recycling (HIR)	
■ Cold Mix and Cold In-Place Recycling	
■ Full Depth Reclamation	
New Mexico	
■ 120 Cold In-Place Recycling Projects	
Constructed Since 1984	
	■ Excellent To Good Performance ■ Assignable Cause For Fair to Poor Performance Performance Performance Data of Recycled Mixtures ■ Hot Mix Asphalt Recycling ■ Hot In-Place Recycling (HIR) ■ Cold Mix and Cold In-Place Recycling ■ Full Depth Reclamation

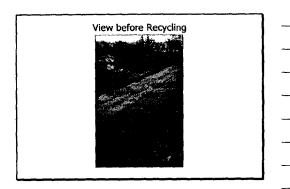
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Performance of CIR Pavements in New Mexico

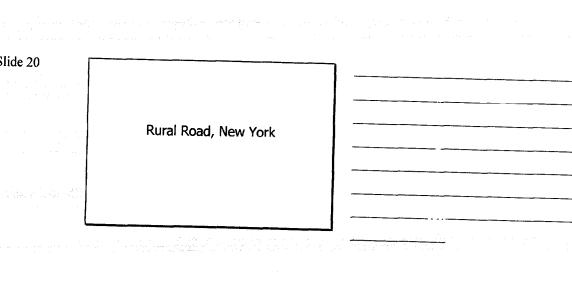
% of Projects	Average PCI	Age (Year)	Traffic, AADT (1995)
91	785 (excellent)	4-12	300- 10,000
9	54-85		,

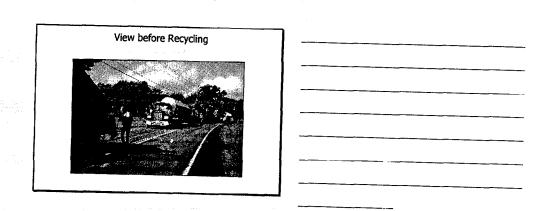
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Rural Road, New York

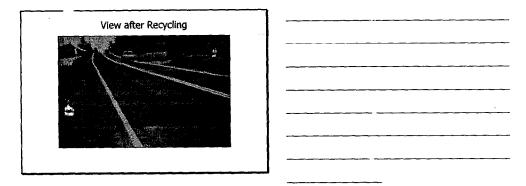


Slide 19 View after Recycling and Application of Hot Mix Overlay Slide 20





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Oregon

- 52 Cold In-Place Recycling Projects Evaluated in 1986
- Traffic Volumes Ranged From Low to High
- 4? Projects: Good Performance
- 5 Projects: Poor Performance Attributed to Too Much Recycling Agent Placing Wearing Course Too Soon
- Major Improvement in Ride Quality

Slide 24

Pennsylvania

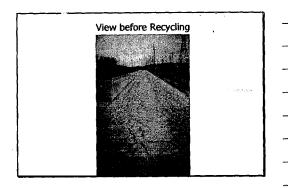
- Over 90 Cold In-Place Recycling Projects Constructed
- Performance Very Satisfactory
- Poor Performance on Some Projects Attributed to Inadequate Wearing Course (For Example, Single Seal Coat Only)

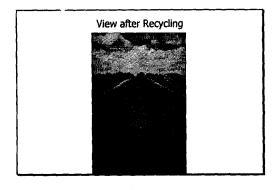
Slide 25		
	Susquehanna County, Pennsylvania	
Slide 26	View before Recycling	
t van de	0	
Slide 27	View after Recycling	

Slide 28	Schuylkill County, Pennsylvania 1983	
Slide 29		
	View before Recycling	
Slide 30	View after Recycling (Good Condition)	

Slide 31	View after Recycling (Poor Condition)
and the state of t	
Slide 32	
10000000000000000000000000000000000000	Performance Data of Recycled Mixtures
	■ Hot Mix Asphalt Recycling
	■ Hot In-Place Recycling (HIPR)
and the second s	■ Cold Mix and Cold In-Place Recycling
	■ Full Depth Reclamation
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Slide 33	
	Rural Road, New Hampshire
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Slide 36

FDR

- Long Term Performance Data Not Available
- Good Experience Reported by Several Agencies

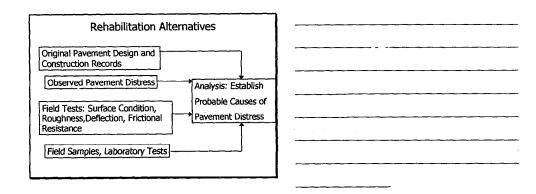
	Slide 37		٦
10 A		FDR	
		■ Increase in Strength ■ Increase in Load Distribution Capability	
		■ Increase in Durability	
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	Slide 38	Summary	
		Performance Data of Recycled Mixtures	
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		Performance Data of Recycled Mixtures	
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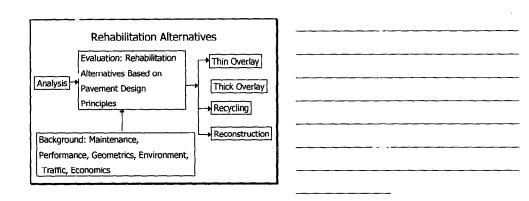
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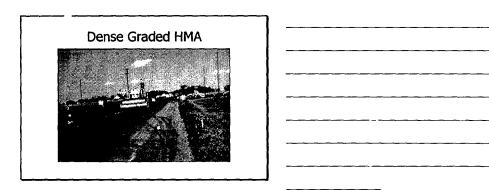
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Slide 1		
	Selection of Pavement for Recycling and	
	Recycling Strategies	12 July 10 Jan Hussianer (1910 - 1910)
		By Millian (1900) (1900
Slide 2	Why Rehabilitate ?	
	■ Inadequate Ride Quality ■ Excessive Pavement Distress ■ Reduced Surface Friction ■ Excessive Maintenance Requirement	
	■ Uninceptable User Costs ■ Inadequate Structural Capacity for Planned Use or Projected Traffic Volumes	
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Slide 3	Recycling is One of the Various	
	Rehabilitation Alternatives	
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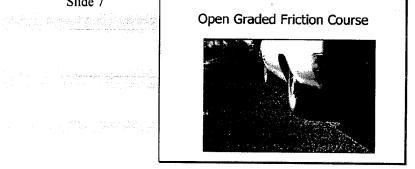


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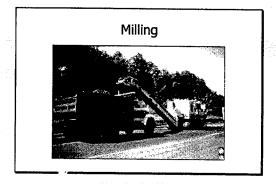




Slide 7



Slide 8



Slide 9

Problem	Rehabilitation Alternatives		
FIODICIII	Re	napilitation i	remoa
	Overlay	Recycling	Reconstruction
Cracking	×	x	X
Rutting	×	x	x
Raveling	X		

Slide 10	f	
Shar To	Selection of Rehabilitation Alternative	
	■ Engineering Consideration	
	■ Economic Consideration	
	- 100 m	
	■ Energy Consideration	
Slide 11	Engineering Considerations	
	Engineering Considerations	
	■ Ride Quality of Existing Pavement ■ Type, Extent and Severity of Distress	
	■ Structural Capacity	
	■ Drainage Conditions ■ Design Life Required	
	■ Material Used in Existing Pavement	
	■ Age of Pavement	
Slide 12	Funition Considerations	<u> </u>
	Engineering Considerations (Continued)	
	■ Type, Frequency and Cost of Past	
	Maintenance	
	■ Construction Considerations ■ Overhead Clearance	
	Curbs and GuttersDrainage Structures	
	 Shoulders, Median Barriers and Guardrails 	

	Slide 13		
•	Side 13	Economic Considerations	
ļ ģ	n de la companya de	■ Comparison Based on Present Value (or Worth)	
		■ Comparison Based on Equivalent Uniform Annual Cost (or Benefit)	
		■ Comparison of Life Cycle Costs	
•			Maria de la companya de la companya La companya de la co
	Slide 14		
		Energy Considerations	
		■ Material Manufacture	
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*		■ Mix Production	
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us C		■ Mix Placement and Compaction	
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	Slide 15		
÷		Final Considerations	W-1
		■ Availability of Equipment	
	e e e e e e e e e e e e e e e e e e e	Availability of Experienced Contractor	
2	"	■ First cost	
		■ Life cycle cost	

Slide 16	"]
	Final Considerations	
	■ Traffic control	
	■ length of construction	
	m impact on adjacent business	
	■ utility relocation and interference	
		1
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Slide 17	Selection of Recycling Method	
	Selection of Recycling Method	
	■ Hot Mix Recycling	
	■ Hot In-Place Recycling	
	■ Cold In-Place Recycling	
	■ Full Depth Reclamation	
		
Slide 18		
	Hot Mix Recycling: Process	
	■ RAP is Combined with New Aggregate and	
	Asphalt Binder or Recycling Agent in a Hot Mix Plant	
	MIX Plant ■ Mix is Transported to Paving Site, Placed and	
	Compacted	

	Slide 19		n of the second of the second
		Hot Mix Recycling: Advantages	
		■ Significant Structural Improvement	
		■ Performance as Good as Virgin Mix	
		Most Surface Defects, Deformation, and Cracking Corrected	11.
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	Slide 20		
		Hot In-Place Recycling: Process	
		 Existing Asphalt Surface is Heated, Scarified to a Depth from 19 to 38 mm 	
		Scarified Material Combined with Aggregate and/or Asphalt Binder and/or Recycling Agent and Compacted	
e era i sing e to a sel	and the second of the family	■ New Overlay May or may Not be Provided	
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	Slide 21		
		Hot In-Place Recycling Process	
		Carpet Tables And S	
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Hot In-Place Recycling: Advantages

- Surface Cracks Eliminated
- Ruts, Shoves, Bumps Corrected
- Aged Asphalt is Rejuvenated
- Aggregate Gradation and Asphalt Content Can be Modified
- Reduced Traffic Interruption During Construction
- Hauling Cost Minimized

S	li	de	23

Cold In-Place Recycling: Process

- Existing Asphalt pavement Milled (75 to 100 mm Depth)
- RAP Sized if Needed, Mixed with Recycling Agent
- Placed and Compacted

Slide 24

Cold In-Place Recycling Operation



	Slide 25	Cold In-Place Recycling : Advantages	
- 510		■ Significant Structural Improvements ■ Most Pavement Distress Treated ■ Ride Quality Improved ■ Hauling Costs Minimized ■ Minimal Air Quality Problems	
Annual Control		■ Pavement Widening Possible	
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		All HMA Layers and Predetermined Thickness of Underlying layer Pulverized	
A Common Andrews		■ Stabilized with Additives	
_		■ Shaped and Compacted	
-		■ Surface Course is Applied	
The state of the s			
A section of			
•	Slide 27	FDR: Advantages	
		■ Most Pavement Distress Treated	
•	1	■ Hauling Cost Minimized	
	The second of th	■ Significant Structural Improvements Especially in Base	
No. of		■ Eliminates Material Disposal Problems	
3		■ Improves Ride Quality	

Recycling Alternatives

ype of Pavement Distress	Hot Recycling	Hot In-Place Recycling
Surface Defects		
Raveling	x	x
Bleeding	X	Х
Slipperiness	l x.	l x

Slide 29

Recycling Alternatives

Type of Pavement Distress	HR	HIR	CIR	FDR
Deformation Corrugations	x	x		
Rutting - Shallow	X	X		
Rutting - Deep	x		x	x

Type of Pavemen	•	Altern		
Distress	HR	HIR	CIR	FDR
Cracking Alligator Longitudinal	X X	×	x x	X X
Pavement Edge	x		х	x
Slippage	х	х		

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Rec Type of Paverner Distress		Alterna HIR	tives CIR	FDR
Cracking Block (Shrinkage) Longitudinal- joint	x x	x	x	x
Transverse Reflection	X X	1	X	X
Non-Load Associat	ed Crackin	ıg		

Distress

- Surface Defects
 Raveling
 Bleeding
 Slipperiness or Polishing
- Deformation
 Rutting
 - Rutting
 - Corrugation or Washboarding

Slide 33

Distress (Continued)

- Cracking (Load Associated)
 Alligator
 Pavement Edge
 Slippage
 Cracking (Nonload Associated)
 Transverse (Thermal)
 Block

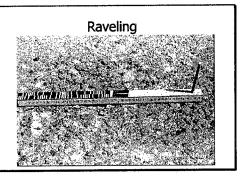
 - Block Longitudinal Joints

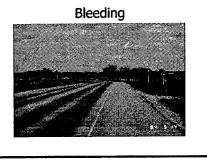
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Distress (Continued)

- Reflective Cracking
- Maintenance Patching

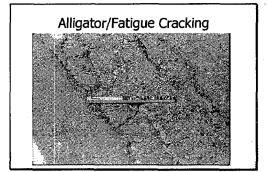
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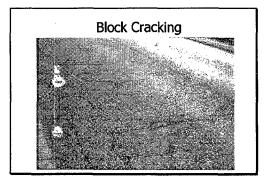


Slide 37 Corrugations Slide 38 Shoving Slide 39 Rutting

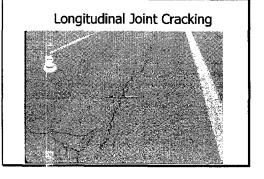




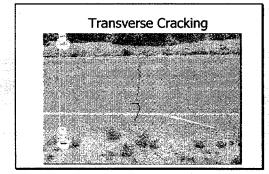
Slide 41



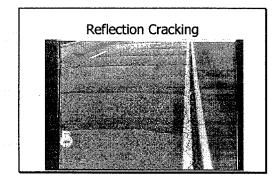
Slide 42



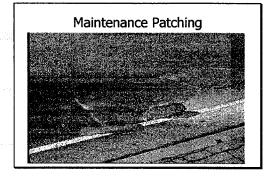
Slide 43



Slide 44



Slide 45



de 46	Applicability and Considerations	
	Process Applicability Considerations Hot Mix Can treat Percentage of RAP depends on deformations, recycled mix cracks, and properties and maintenance type of plant patching	
le 47		
	1	
	Applicability and Considerations	
	Process Applicability Considerations Hot In- Can treat Sufficient amount	
	Process Applicability Considerations	
	Process Applicability Considerations Hot In- Can treat Sufficient amount of work and space corrugation and surface rutting, longitudinal and slippage crack sealing material	

Applicability and Considerations

Applicability Process Cold InPlace
Recycling
R

Considerations maneuvering space.

Slide 49	Applicability and Considerations	
	Process Applicability Considerations	
own son i har a stall be a little was hydging.	Full Depth Can treat Requires wearing Reclamation rutting in sub- surface layers; require significant particularly amount of curing	
	suitable for time; lack of proper roads with base guidelines; problems or experienced insufficient supervisor needed structural capacity	
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Slide 50		
	Summary	
	Selection of Pavement for	
ter to the execution of the	Recycling	
	and	
	Recycling Strategies	
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Slide 51		
	Selection of Pavement for	
	Recycling	
	and	
	Recycling Strategies	
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Economics of Recycling

Slide 2



Slide 3

Savings by Using RAP

Percent of RAP	Cost/Ton	Savings (\$/Ton)	Savings (%)
0 %	11.90	(,,	•
20.%	10.26	1.64	14
30 %	9.44	2.46	21
40 %	8.62	3.28	28
50 %	7.80	4.10	34

Slide 5

Sumn	nary of Co	st Saving	s- FHWA Surve	y (1984)	
Area	Total Tonnage (1000) 1984	Average Savings Per Ton (\$)	Average % Savings versus 100% New Material (\$)	Total Savings (\$1000)	
North-	500	2.80	10	1400	
East					
South- East	4,000	5.67	20	22,300	
North- Centrai	12,000	5.26	18	62,600	
South- Central	2,000	5.32	20	10,000	
Western	1,600	5.12	21	8,200	
Total	20,000			104,500	
Average		4.83	18		

Slide 6

Typical Cost Savings : Hot Mix Recycling

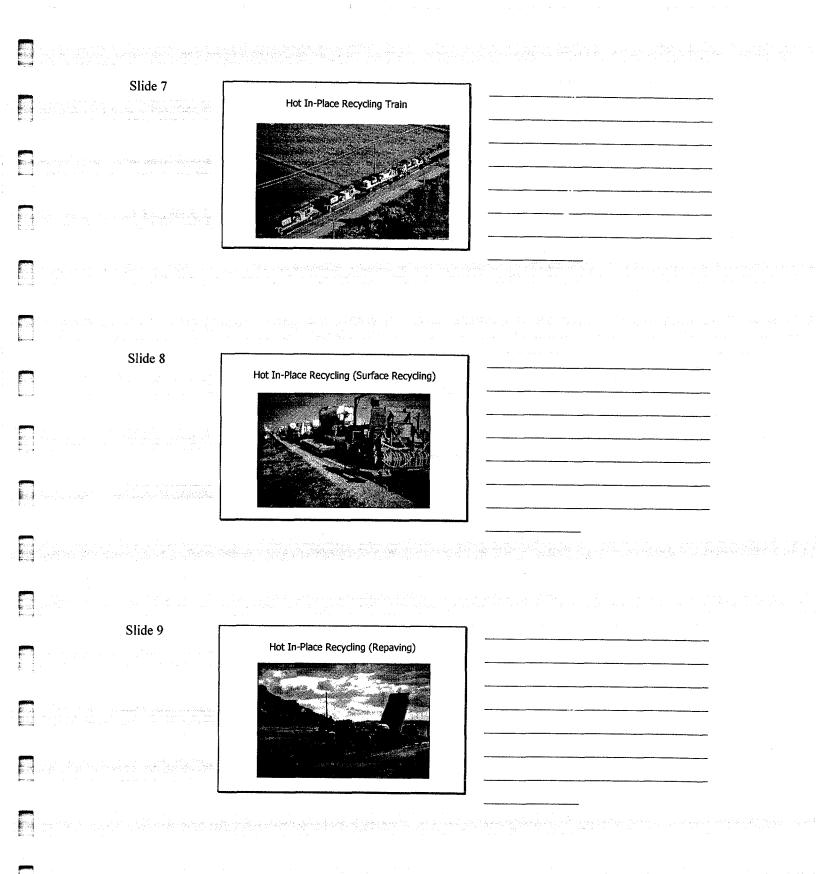
 Agency
 Year (s)
 % Average Savings

 Florida DOT
 1981-1983
 24-26

 Saskatchwan
 1985
 20-30

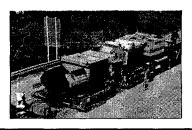
 U.S. Corps of Engineers
 1986
 16

 Wisconsin DOT
 1980-1985
 39-49



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Hot In-Place Recycling (Remixing)



Slide 11

Typical Costs of Hot In-Place Recycling (Table)

Method

Cost (\$/sq.m)

A. Heater Scarification 1.2

B. Repaving 25 mm Recycling + 25 mm HMA Overlay

2.8-3.7 (50 mm depth)

C. Remixing 25 mm Recycling + 20 36 New Aggregate

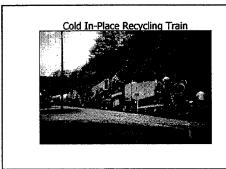
Slide 12

Savings with HIR

Savings over Control (%) Agency HIR Process Florida DOT Repaving 25 FAA Texarkana, Texas Repaving 50

Savings with HIR				
Agency	HIR Process	Savings over Control (%)		
Mississippi SHD	Remixing	40		
Oregon DOT	Remixing	17		
Texas DOT	Remixing	34		

Slide 14



Slide 15

Typical Costs of Cold In-Place Recycling

Oregon DOT (1989-1990)

5 cm Cold Recycling
with Chip Seal

5 cm Cold Recycling
without Chip Seal

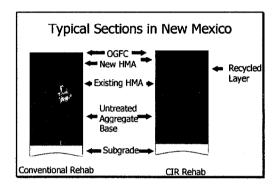
1.80

Cost (\$/sq.m)

Percent Cost Savings

State California Iowa Kansas Missouri Montana Oregon Pennsylvania Vermont	% Cost Savings 21- 37 67 53 50 21 24 16 28-31
Vermont	28-31

Slide 17



Initial (Initial Construction Cost in New Mexico			
Savings	Maximum	Minimum	Average	
\$/lane-km	14,296	1,593	7074	
\$/square m	2.81	0.53	1.90	

Slide 19			-	
	Life Cycle Cost in New Mexico			
	Rehab Initial Cost Maintenanc Total Cost Option (\$) e Cost (\$) (\$/m²) Mill and 8.78 0.314 9.09 Overlay (Total)			
	CIR (Total) 6.88 0.159 7.04			
e for the state of the first of the con-	Cost 1.90 0.155 2.05 Savings with CIR			

	in de la companya de La companya de la co	Villa September 1997 tel		
Slide 20				
l l	Savings with CIR	***************************************		
Slide 20	Savings with CIR Maintenance of Cracked Pavements			
l l	_			
	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay			
	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay Projects			
	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay Projects			
	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay Projects After 8 Years for CIR Projects			
	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay Projects After 8 Years for CIR Projects			
	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay Projects After 8 Years for CIR Projects			
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	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay Projects After 8 Years for CIR Projects			
	■ Maintenance of Cracked Pavements After 4 Years for Mill and Overlay Projects After 8 Years for CIR Projects			

Slide 22		•
	Savings in FDR	
	Option Cost	
	Full Reconstruction: \$16.12/m²	
	Excavate, place grade and compact, and pave	
	FDR and pave \$7.25/m ²	
		<u> </u>
Slide 23	Savings with Rogycling	
	Savings with Recycling	
	■ Savings is also Achieved by	
	Not Transporting RAP	
	And	
	Not Using Landfill Space	
		<u> </u>
Slide 24		1
Silue 24	Recycling	
	■ Recycling Reuses Non-Renewable Resources	
	# Recyaling Reases Non-Relievable Resources	
	■ Should be Used Even if Cost is Equal to	
	Conventional Rehabilitation Options	
	■ Better Option in Many Cases	

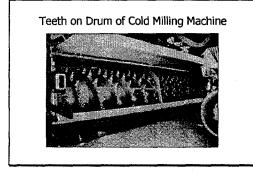
bole sol			
	Slide 25	Better Option When Overlay is Limited to Maintain Underpass	
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	•		
	Slide 26	Summary	
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	in the second product that the book of the		
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	Slide 27		
E C		Economics of Recycling	
		???	
		and the second of the second o	en e

	Slide 1	Hot Mix Asphalt	
	and the second second	Recycling: Batch Plant (Construction Methods and Equipment)	
		and Equipment)	
	स्ट्रांटिक सम्बद्धाः स्ट्रांटिक स्ट्रेस स्ट्रांटिक स्ट्रांटिक स्ट्रांटिक स्ट्रांटिक स्ट्रांटिक स्ट्रांटिक स्ट्र	an ing kalanggangganggangganggangganggangganggan	til som en statiske skiller kommen skiller skiller skiller skiller skiller skiller skiller skiller skiller skil Skiller skiller skille
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	Slide 2	Hot Mix Asphalt Recycling	
Electrical designation of the second		■ Batch Plant	
	e pro la la glicació de diagra d'Astaji.	■ Drum Plant	
		and the state of t	
	Slide 3	Batch Plant Drum Plant	
wares			
		The state of the s	

Slide 4		
	Topics	
	■ Removal of Existing Pavement	
	■ Crushing and Stockpiling	
	■ Modifications to Batch Plant	
	■ Recycling Processes in Batch Plant	
01:1 6		_
Slide 5	Topics	
	■ Removal of Existing Pavement	
	■ Crushing and Stockpiling	
	■ Modifications to Batch Plant	
	■ Recycling Processes in Batch Plant	
		Additional Association and Ass
Slide 6		
	Removal of Existing Pavement	
	■ Cold Milling	
	■ Ripping and Crushing	
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to one of the sec	Slide 7	Cold Milling ■ Significant Development for Recycling	
		■ Most Widely Used ■ Removes HMA Surface to Specified Depth	
T 4 1 1 5		■ Provides Uniform Profile and Cross Slope	
	o de la secono de la companio de la La companio de la co	ti kan bang di kanangan distrikan dalam kangan dan sebagai kangan dan dalam dan sebagai bang bang bang bang ba Bang bang bang bang bang bang bang bang b	nas sakselama gara bergilikan parti dan sejara barah dalam Tanah sakselama
	Slide 8		
-	Slide o	Typical Surface Resulting from Cold Milling	
-seral			
	and the second s	election resident date	
- 104 - 104 - 11 - 114 - 11			
1 2 2 - 3 - 3	Slide 9	na militaria de la composición de la c La composición de la	
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Slide 13	ૈપાી Lane Cold Milling Machine	
	III Late Cold Pilling Placinie	
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	n of the second consistency of the second co	
Slide 14	Full Lane Cold Milling Machine	
	Tall Larie Gold Things	
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to the second of	aka da gaja jarah kata kanga an anggang kana maga amatan ana ana ana ana ana ana ana ang an	gi di Karaban ang manakan da maga aya da mada ay ay ang ada an ang
Slide 15		
and the second of the second o	Removal of Existing Pavement	
	■ Cold Milling ■ Ripping and Crushing	
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Ripping and Crushing

- Existing Roadway to be Upgraded for Heavy Traffic
- Existing Roadway of Uniform Material

Slide 17

Pavement Ripping with Dozer

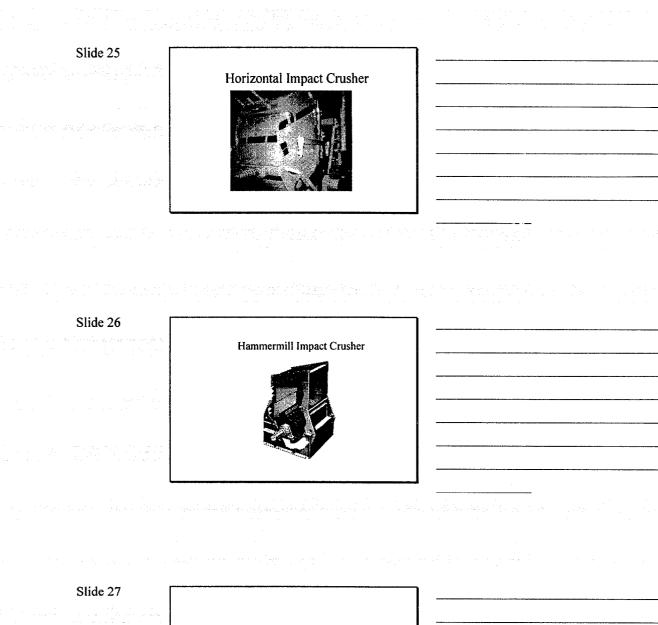


Dozor with Rear Mounted Ripper Tooth



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Slide 19	Ripping and Crushing	
	The second secon	
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Slide 20	Topics	
	■ Removal of Existing Pavement	
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	■ Crushing and Stockpiling	
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	■ Modifications to Batch Plant	
	■ Modifications to Batch Plant ■ Recycling Processes in Batch Plant	
	■ Modifications to Batch Plant ■ Recycling Processes in Batch Plant	
Slide 21	■ Modifications to Batch Plant ■ Recycling Processes in Batch Plant	
Slide 21	■ Modifications to Batch Plant ■ Recycling Processes in Batch Plant	
Slide 21	■ Modifications to Batch Plant ■ Recycling Processes in Batch Plant	

Slide 22		1
	RAP Breaker	
	And the second s	
	Breaker	
Slide 23		
	Types of Crushers	
	■ Compression Crusher	
	■ Impact Crusher	
Slide 24		1
Silue 24	Primary Jaw Crusher	



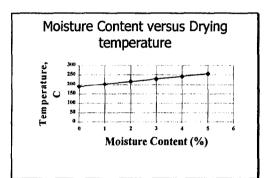
Slide 28	Typical Use of Jaw/Roll Crusher Double deck screen used for two products: Fine (< 12.5 mm) Coarse (12.5 - 19.5 mm)	
Slide 29	Pancaking ■ Formation of dense mass of RAP	
	■ Especially in Warm, humid days ■ Problem in Jaw/Roll Crushers	
Slide 30		
	Steps in Crushing RAP	
	■ Blend RAP thoroughly ■ Crush RAP to One Smaller than Top Size in HMA	

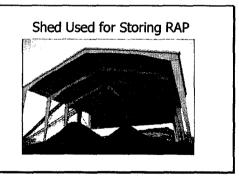
Slide 31		
Sindo ST	Crushing of RAP	
	■ Crush Material in Small Quantity	
a a company of the second seco	Easier to Sample	
j	Easier to Identify Material	
	Can be Used Quickly	
<u>.</u>		
	and the first of the second of	and the state of t
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Slide 32	•	
Residence of Authorities as	Stockpiling	
	■ Separate Based on Sources/Mix Types	
3	■ Avoid Consolidation	
of the state of t	No Loaders, Dozers or Trucks on Stockpile	
	■ Protect from Moisture Intrusion	
	■ Protect from Contamination	
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Slide 33		
Since	Radial Stacker for Stockpiling RAP	
	Nove N	

RAP Piles

- Use Conical RAP Piles
- Crust Helps to Shed water
- Crust is Easily Broken by Frontend Loader
- Prevents Compaction

Slide 35





Slide 37	Topics			
	Topics			
	■ Removal of Existing Pavement			
	■ Crushing and Stockpiling	<u></u>		
and the New York Charles	■ Modifications to Batch Plant		A	
	■ Recycling Processes in Batch Plant			
			Maria Caracana Caraca	
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Slide 38				
Slide 38				
Slide 38				

Superheating Aggregates

- Aggregate Dryer
 - Adequate Veil
 - Cooling Period to Avoid Warping
- Dryer Exhaust System
 - E Lower Temperature to Prevent Damage to Baghouse

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RAP Feeder and Conveying System

- ⊞RAP Cold Feed Bin
 - Steep Sides, Large Discharge Opening
- □RAP Conveying System
 - Heavy Duty Motor to Ensure Frequent Starting and Stopping

Slide 41

Photograph of RAP Cold Feed Bin



Slide 42

Photograph of RAP Conveying System



Slide 43	Maintage and Dust Emissions	
Annual phase such that security is a second of the second	Moisture and Dust Emissions	
n de la companie de l	Adequate Venting for Weigh Hopper and Pugmill	
The state of the s	Moisture Emission Depends on Moisture Content of RAP Material	
11 - 12 - 13 - 14 12 13 13 13 14 1 5 2 1 14 15 2 1 14 15 14 15 15 15 15 15 15 15 15 15 15 15 15 15	n, om op <mark>ter setter na protes</mark> og skriver og det en	
Slide 44		1
	Storage Silos	
	■ Allow Heat Transfer and Attain Temperature Equilibrium	
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		n jan padagan, kan dibupat lejar.
Slide 45	Topics]
	Removal of Existing Pavement	
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	■ Modifications to Batch Plant ■ Recycling Processes in Batch Plant	
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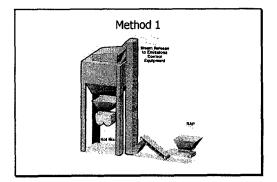
Recycling Processes

- ⊞Method 1
 - RAP Fed into Boot of Hot Elevator
- ⊠Method 2
 - RAP Fed into Boot of Hot Elevator, Bypasses Screen, Goes into Fifth Hot Bin
- ⊞Method 3
 - RAP Fed into Weigh Hopper

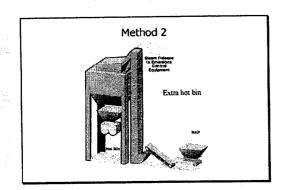
Slide 47

Recycling Processes

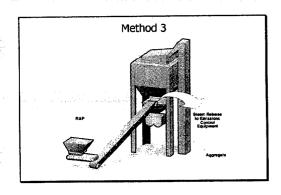
- ⊌:Metnod 4
 - SRAP Fed into a Bin which Discharges Directly into the Pugmill
- Method 5
 - Preheating RAP in Separate Dryer

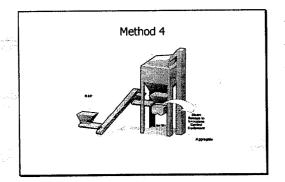


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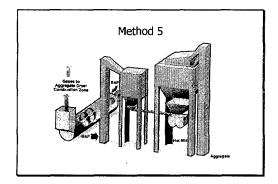


Slide 50





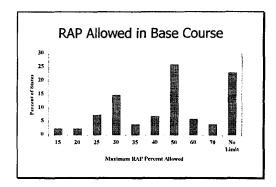
Slide 52



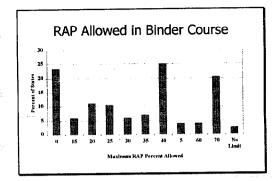
Amount of RAP

- Factors
 - Moisture Content of RAP
 - Temperature of Superheated Aggregate
 - Temperature of RAP
 - Temperature of Recycled Mix
 - Percent passing 0.075 mm Sieve
- Amount of RAP
 - Maximum :About 50 % Practical : About 30 %

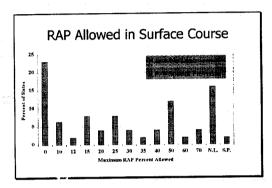
Slide 54



Slide 55



Slide 56



Slide 57

Summary

Hot Mix Asphalt Recycling: Batch Plant (Construction Methods and Equipment)

Slide	58
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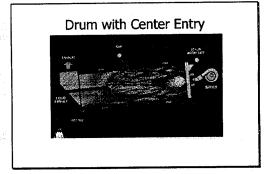
Hot Mix Asphalt Recycling: Batch Plant (Construction Methods and Equipment)

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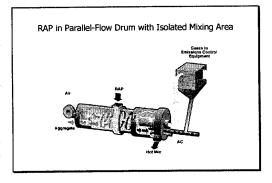
Slide 1	· · · · · · · · · · · · · · · · · · ·	
Termo ji war kuhurini Pauk (August) (August	Hot Mix Asphalt Recycling: Drum Plant (Construction Methods and Equipment)	
	and Equipment)	
		language (n. 1945) 1980: Alexandra (n. 1945) 1980: Alexandra (n. 1945)
Slide 2	Hot Mix Asphalt Recycling	
Transles - The money of the process which	■ Batch Plant ■ Drum Plant	
k De skriver kenner groot en beskriver genoemde De skriver kenner groot en beskriver genoemde	and the content of properties and the content of th	en la la participa de la companya del companya de la companya del companya de la
Slide 3	Advantages of Recycling in Drum	
	■ Portability ■ High Percentage of RAP	
	■ High Production Rates ■ More Homogeneous Mix	

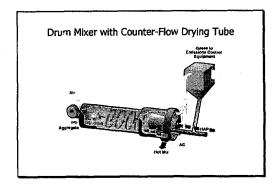
Slide 4		
•	Topics	
	■ Removal of Existing Pavement	
	■ Crushing and Stockpiling	
	■ Recycling Process in Drum Plants	
	■ Amount of RAP	
Slide 5		ן
	Topics	
	■ Removal of Existing Pavement	
	■ Crushing and Stockpiling	
	■ Recycling Process in Drum Plants	
	■ Amount of RAP	
		·
Slide 6		
	Center Entry Method	
	■ Most Widely Used	
	■ RAP Introduced in Drum, Downstream of Burner Flame	<u>.</u>
	■ Veil of Aggregate Protects RAP	
	■ Zones in Drum for Drying/Heating Aggregate & RAP and Mixing	
	<u></u>	∴

Slide 7

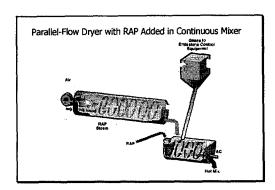


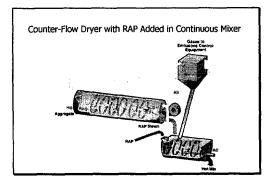




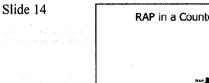


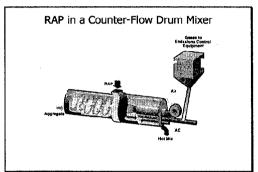
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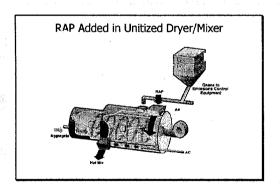




Slide 13 RAP Added in Counter-Flow Aggregate Dryer







Double Barrel

- Double Barrel, Counterflow Drum
- Aggregate Superheated in Inner Drum
- Meets RAP in the Annular Space
- Addition of Binder and Mixing in the Annular Space
- Shell of Inner Drum Used as Shaft of Coater
- Outer Shell Does Not Rotate

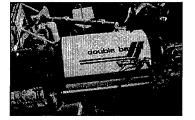
Slide 17

Schematic of Double Barrel Mixer



Slide 18

Double Barrel Drum



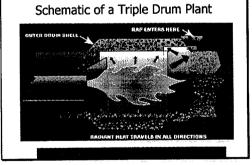
Advantages of Double Barrel

- RAP and Asphalt Binder Not Exposed to Hot Gases
- Very Heat Efficient/Low Fuel Consumption
- Very Low Emissions
- Longer Life of Bags in Baghouse

Slide 20

Triple Drum

- Uses Stainless Steel Cylinder to Enclose Combustion Chamber
- Counterflow Drum
- RAP Material Introduced in Annular Space Formed by Outer Shell
- Superheated Virgin Aggregates Meet RAP in Antuiar Space





Slide 23

Advantage of Triple Drum

■ The Stainless Steel Cylinder is Effective in Transferring Heat to the RAP Material through Conduction and Radiation

Slide 24

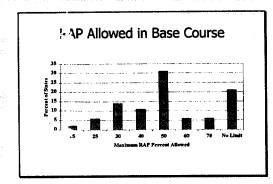
Amount of RAP in Drum Plant Recycling

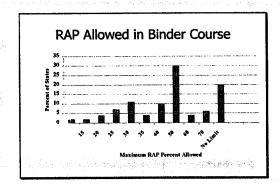
■ Factors

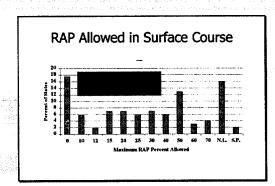
Moisture Content of RAP
Temperature of Superheated Aggregate
Temperature of RAP
Temperature of Recycled Mix

■ Amount of RAP Maximum: About 70 % Practical: About 30 % - 50 %

Slide 25







		🚤
Slide 28	Feeder Systems ■ Bin Low Capacity Steep Sides Long and Wide Bottom ■ Material should be Dribbled	
Slide 29	Feeder Systems	
	■RAP	
	Do Not Leave in Bin for >2 Hours	
	■ Feeders	
	Wide and with Sufficient Horsepower	
	■ Vibratory Feeders Not Recommended	
Slide 30		1 ·····
Bilde 30		
	Summary	
	Hot Mix Asphalt Recycling: Drum	
	Plant (Construction Methods and	
	Equipment)	

	Slide 31	Hot Mix Asphalt Recycling: Drum Plant (Construction Methods and Equipment)	
4.	will be a second	???	
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	Slide 1		
	n en en eg kook en en ekkelender. En en en eg kook en en ekkelender en ekkelender.	Hot Mix Asphalt Recycling (Case History and QC/QA)	
		ta diga kangda San Bapataliga da garawal jantah kang makang ili menghili menghili menghili menghili menghili m Kangda kangda San Bapataliga da garawal jantah kangda kangda kangda kangda kangda kangda kangda kangda kangda	anagiya (1981) aday girijahan ya masa sanga ya asili sa Tarih
	Slide 2	Case History	
A 31			
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	and by the second control of the second second	and the second of the content of policy will be a second or the second of the second o	la di Bernesia di Germani Indonésia awa 17 km na kabupatan katana katana katana katana katana katana katana ka
₽ च		Lebanon County Pennsylvania	
	e meneral di salah s Salah salah sa	Traffic Route 72 Recycled Base Course Mix Used	
		1982	

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Lebanon County

■ Traffic

ADT: 5000

Truck Traffic: 20 %

Slide 5





Slide 6

Analysis of RAP

- Mix Composition (N = 10)

 Asphalt Content 5.7%

 Gradation
- Abson Recovery (N = 3)
 Viscosity (60°C)
- 20% RAP to be Used in Batch Plant

	Grada	ation of	Aggre	egate	
Sieve	RAP 20.0 %	2B 63.3%	FA 16.7 %	Total 6 Blend	Spec.
38 mi	m 100	100	100	100	100
12.5 mm	100	50	100	68	40-75
4.75 mm	84	4	100	36	20-47
2.36 mm	65	2	76	27	15-37
0.075 mm	18	0.3	6.5	4.9	2-6

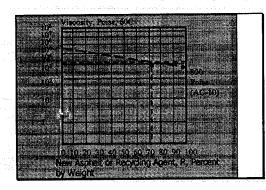
Slide 8

Calculation of % New Asphalt in the Total Asphalt

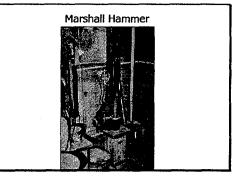
$$\begin{split} P_{ab} &= \frac{(100^2 - rP_{ab})Pb}{100(100 - P_{ab})} - \frac{(100 - r)P_{ab}}{100(-100 - r)} \\ &= \frac{(100^2 - 80 \times 5.7)4}{100(100 - 5.7)} - \frac{(100 - 0)5.7}{100 - 5.7} \\ &= 2.8 \end{split}$$

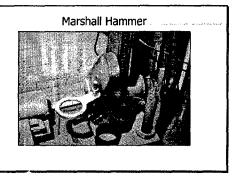
 $\begin{array}{l} P_{nb} = \text{Percent of New Asphalt Binder in Recycled Mix} \\ r = \text{New Aggregate}, \text{Percent of Total Aggregate} \\ P_{b} = \text{Estimated Asphalt Content of Recycled Mix} \\ P_{sb} = \text{Asphalt Content of RAP Material} \end{array}$

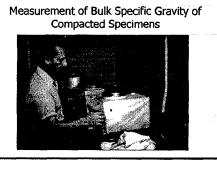
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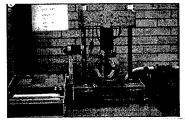
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Slide 14

Recycled Base Course Mix Composition

- RAP
- AASHTO 57

- **■** Fine Aggregate
- 20.0%
- 63.3%
- Asphalt Content: 4.0 %

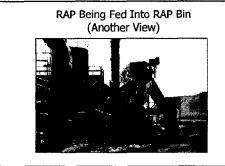
16.7 % 100.0 %

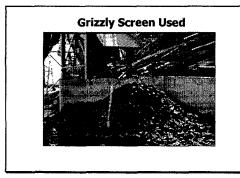
Slide 15

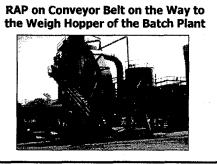
RAP Being Fed Into RAP Bin



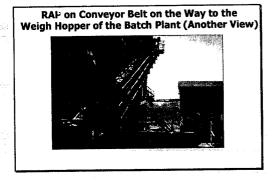
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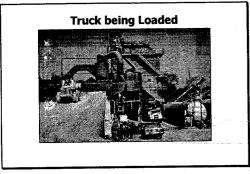




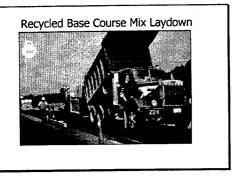




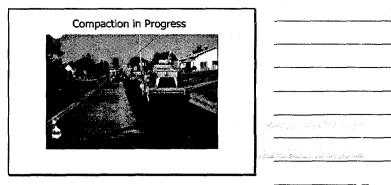
Slide 20

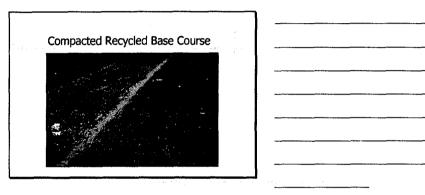


Slide 21



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	84	ue	22





	T	est Dat	a	
N = 31	2.36 mm	0.075 mm	% AC	% Voids
Design	27.0	4.9	4.0	5.5
Mean	26.5	5.6	4.0	4.5
Std. Deviation	1.3	0.6	0.17	0.5
95 % C.L. (,)	2.6	1.2	0.34	1.0

Slide 25 **Control Charts** Slide 26 Finished HMA Slide 27 Performance ■ Distress Survey after 10 Years Indicated No Significant Difference Between Control and Recycle Section in terms of Rutting and

Cracking

Slide 28	Quality Control (QC) and Quality Assurance (QA)	
Slide 29	QC/QA Similar to Conventional HMA Mixes Additional Testing for Recycled Mixes Composition of RAP (Asphalt Content and Gradation) Consistency of Binder Recovered From Recycled Mix	
Slide 30	Aggregate Gradation Aggregate Stockpile RAP Stockpile Cold Feeder Belt Hot Bins (Batch Plant) Aggregate Recovered by Extraction or Ignition of Recycled Mix	

Slide 31	<u> </u>	า
Since 51	Asphalt Content	
	■ Solvent Extraction	
and the second of the second o	■ Nuclear Asphalt Content Gauge	
	■ NCAT Ignition Method	
ang mentangan salah pada salah s		
en e	kan distribution of the state o	in 1995 <u>ann an Airean Said</u> a. Canada an Airean an
Slide 32		
	Testing Recovered Asphalt Binder	
	■ Test Recovered Asphalt Binder	
	→ Viscosity (60°C)	
	→ G*/Sin delta	
er en samme en en en en samme en samme en		
	ras versus som skled i stalveliklaridd - gold gold o'r	
Slide 33		
Since 33		
	Field Management of Volumetric Properties	
and the second of the second o	'	

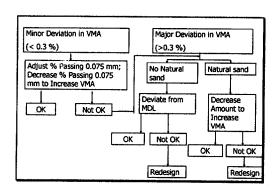
Volumetrics Properties

m VMA

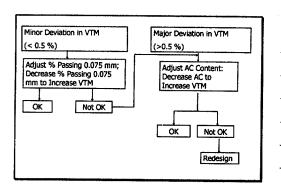
- No. 2.36 (Amount of FA) Sand)

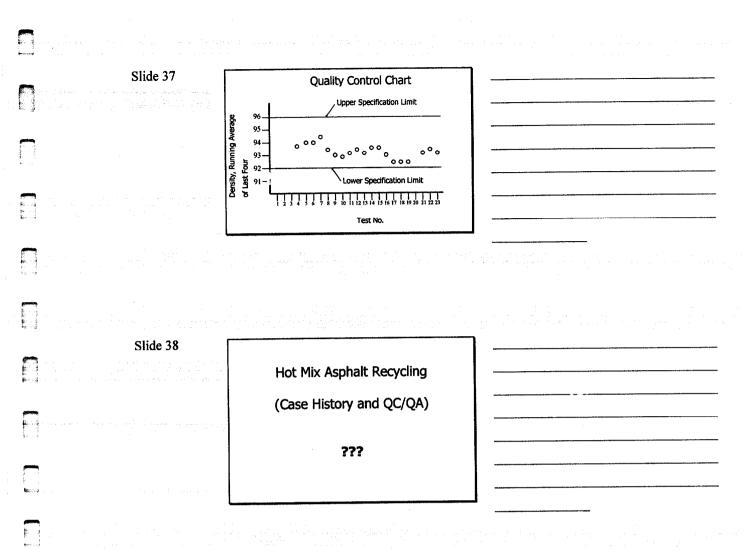
- Asphalt Content
 Passing 0.075 mm
- 2.36 mm through 0.15 mm

Slide 35



Slide 36





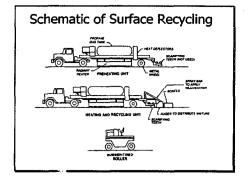
Slide 1		
	Hot In-Place Recycling (HIR) Construction	
	Methods & Equipment	
		Security and the contract of t
Slide 2	Description	
	■ On site, Hot In-Place Method That Rehabilitates Deteriorated Asphalt Pavements and Thereby Minimizes Use	
⊶	of New Materials ■ Depth Recycled: 20-50 mm (25 mm	
	Most Common)	
		e transport en la companya de la co Companya de la companya de la compa
Slide 3	4 Basic Steps	
	■ Softening Pavement with Heat	
	 Scarification or Mechanical Removal of Softened Material 	
ready	■ Mixing with Recycling Agent, New Aggregate, New Binder, or New Mix	
	■ Laydown and Paving	
_		
		n All de Mediter (Million de la companio (Million de La Companio) (Companio de La Companio de La Companio de L La companio de la Co La companio de La Co

Slide 4		7
SHUC 4	Advantages of HIR	
	Navanages of Tark	
	■ Pavement Geometrics Preserved	
	■ Corrects Surface Distresses Not Caused	
	by Structural Inadequacy	
	■ Can Modify Existing Surface Mix	
		J
		and the second s
Slide 5		
	Advantages of HIR	
	■ Can Improve Surface Frictional	
	Resistance	
	■ Relatively Cheap	
	■ Needs Less Traffic Control	
Slide 6		7
	HIR Processes	
	■ Surface Recycling	

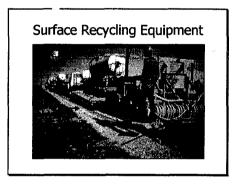
	■ Repaving	
	■ Remixing	
	<u> </u>	

Slide 7		
	HIR Processes	
	■ Surface Recycling	
	■ Repaving	
	■ Renuxing	
Slide 8	Surface Recycling	
no radio de la constanta de la Decembra	■ Rehabilitation Process That Restores	
	Cracked, Brittle, and Irregular Pavement in Preparation for a Final	
	This ·Vearing Course	
	■ Depth of 20-25 mm Most Common (50 mm Possible)	
	nin rossible)	<u> </u>
	esti interesti bi interesti del emparetti e con e con est	en e
	[12] [13] [13] [13] [13] [13] [13] [13] [13	
		inger († 1864) 1880 – Park Brother, fra de frankriker beskriver fan de frankriker fan de frankriker fan de frankriker fan de 1888 – Brother Brother, frankriker fan de frankriker fan de frankriker fan de frankriker fan de frankriker fan
Slide 9		1
	Surface Recycling	
ikanik da je september da para da september 1991 ili sama da se	■ Single-Pass Method	
	■ Two-Pass Method (HMA Overlay Placed	
x4 - Frank State (1915) in the state of th	as a Separate Operation After surface recycling)	
🚚 - Santa Kasamana Santa Asala Asala a		

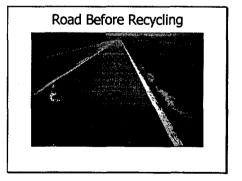
Slide 10



Slide 11



Slide 12



Slide 13 Recycling Slide 14 Road After Recycling Slide 15 Scarifier in Surface Recycling

Slide 16	Recycling in Residential Area	
Slide 17	Surface Recycling ■ Radiant or Infrared Heating	
	 ■ Propane - Most Common Fuel ■ Spring Loaded Scarifiers ■ Effectiveness of Adding Recycling Agent without Mixing 	
Slide 18		

HIR Processes

- Surface Recycling
- Repaving
- Remixing

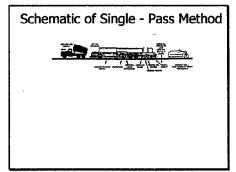
Slide 19	Repaving	
taga sa ang kanalina aga kalam ana mangkaling ang sanda	■ Definition: Surface Recycling Method Combined with Simultaneous Overlay of New HMA to Form a Thermal Bond Between Recycled and New Layers	
	■ Depth: 25 to 50 mm	
Slide 20	Steps in Repaving Process	
	Multiple Heating Units to Soften Asphalt Surface	
ere katoliko kurungan katolika di katolika katolika katolika katolika katolika katolika katolika katolika kato Katolika katolika ka	■ Scarify Softened Pavement	
nn e nghi na kala e kwambili ya washin	■ Add ::nd Mix Recycling Agent with RAP	
ing di kacamatan di Sababata Kacamatan Kababatan di Kababatan		
Slide 21	Steps in Repaving Process	
	■ Spread the Recycled Mix with Screed	
a de la compania del compania de la compania del compania de la compania del compania de la compania de la compania de la compania de la compania del compania de la compania del compania de la compania de la compania del compania de la compania de la compania de la compania del compania	■ Spread the New Mix with Screed on Top of the Recycled Mix	
	■ Compact both Layers of Recycled and New Mixes	

Slide 22		7	
	Advantages	1	
	■ Elimination of Minor Rutting, Shrinkage,		
	Cracking, and Raveling		
	■ Very Thin Overlay (12 mm) Can be		
	Used to Yield Economical, Skid-		
	Resistant, and Virgin HMA Surface	1	
	*	1	
Slide 23		7	
	·		
	Repaving Process		
	■ Multiple - Pass		
		-	
	■ Single - Pass		Augustine and Control of the Control
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Slide 24]	
	Panavina Process		
	Repaving Process		
	■ Multiple - Pass		
		ı	

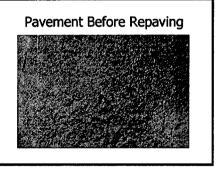
■ Single - Pass

Slide 25	Schematic of Multiple-Pass Repaving	
	Solicinate of Materials Reporting	
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	All Andrews and Parameters and Param	·
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	Adapts agree administ 1 as Cover regions 1 by 1 Tags gar	***************************************
	in the grown was in the property of the community of the second	en e
		·
Slide 26		
Slide 26	Multiple - Pass Repaving	
Slide 26	Multiple - Pass Repaving	

Slide	28
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Slide 31 Single - Pass Repaving Slide 32 Pavement After Repaving Slide 33

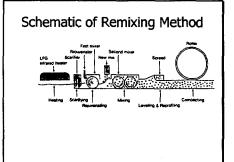
Remixing Process

- Heating Asphalt Pavement 37.5-50 mm
- Scarification and Collection of RAP in Windrow
- Add Virgin Aggregate, Recycling Agent, or Virgin HMA Mix
- Mix in a Pugmill
- Spread Recycled Mix and Compact

Slide 35

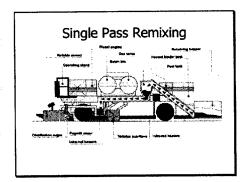
Advantages

- Elimination of Rutting, Cracking, and Oxidation in Top 50 mm of Asphalt Pavement
- Restoration of Existing Asphalt Mix to Desired Mix Composition and Strength by Adding New Aggregate, Binder, or New Mix



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Slide 37



Slide 38





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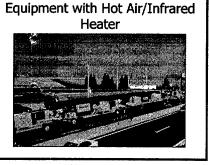




Slide 42



Slide 43 Problem with Crack Filling Material Flare-ups Can Occur Under Preheaters Can Use Strip of Sand or Hydrated Lime If Present in Excessive Amount, Material Mus* Be Removed Slide 44 New Development Use of High Intensity Infrared Heaters Overheat and Damage Asphalt May Cause Emission New Equipment use Hot Air/Low Level Infrared heat

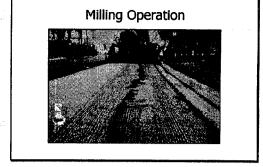


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Slide 46	Summary Hot In-Place Recycling (HIR) Construction Methods & Equipment	
Slide 47	Hot In-Place Recycling (HIR) Construction Methods & Equipment	

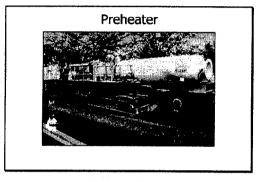
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Slide 1	Hot In-Place Recycling (HIR) Case Histories and QC/QA	
an en la la casa de la casa personal de la proprieta de la casa de La casa de la casa de		
Slide 2	HIR	
And the second s	■ Existing Pavement Heated	
	■ Scarified	
	■ Mixed with Virgin Aggregate and/or Recycling Agent and/or Virgin HMA	
	■ Lair¹ and Compacted	
Nama a sakanda kalayan katawi		en <u>alle de la companya del companya de la companya del companya de la companya d</u>
		epineg i ang pagalang a kanakatan kada ang ang ang ang ang ang ang ang ang an
Slide 3	Types of HIR	
and the second s	■ Surface Recycling	
	■ Repaving	
algebra, who we adjust to the traction of the segment of the segme	■ Remixing	
	de na del gyaleja selletys teppothet (j.e., d., et e	en <u>la companya di manana </u>
Market Community of the Community of	ang makan menganggan kebagaan babangan digan br>Sanggan penganggan digan d	stage what the type promiting is a consensurable to a consensurable to the consensurable of t

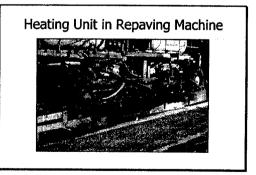
Slide 4	Repaving Process Orange County, Florida Case History	
Slide 5	Orange County Trailic ADT: 33,000 Truck Traffic: 10 %	
Slide 6	Cracks in Existing Pavement	



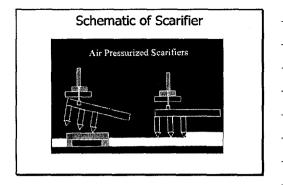
Slide 8

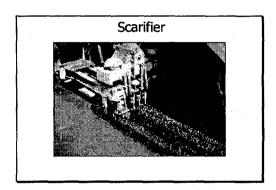


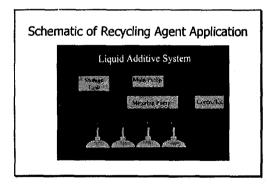
Slide 9

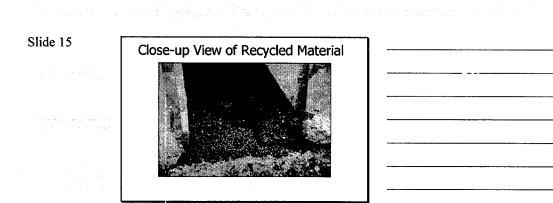


Slide 10

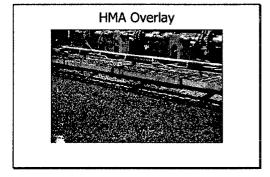




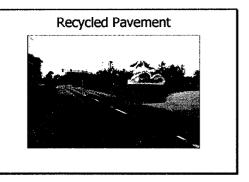




Slide 16

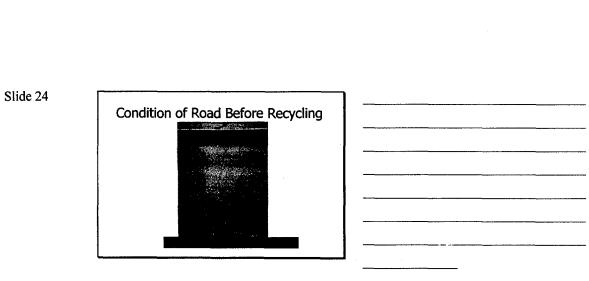




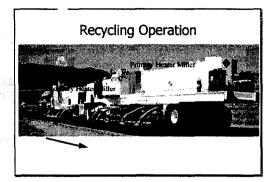


Slide 19		
	Cost of Recycling	
	■ \$3.44 per m²	
	■ Minimum Area of Recycling Required: 60,000 m²	- CONTROL CONT
	Bullion (p. 12) and the second of the second	
Slide 20		
	Case History	
en e	HIR in Highway 3:14 and 3:16,	
	Canada	
	1993	
Slide 21		
	Existing Pavement	
	■ AADT of 3,040	
	■ 50-70 Cracks per km	*****
	■ Distorted Transverse Cracks	
in the second se	■ 2-14 mm rutting	
		Company and Compan

ide 22	HIR	
	■ HIR to a depth of 40 mm	
	■ 0.3 % Recycling agent added	
	■ 10 ". blend sand added	
	■ 75-Blow Marshall testing performed on recycled mix	
		i
de 23		



Slide 25



Slide 26



Slide 27

	Cost		
Cost	HIR	HMA Overlay	
Cost per m ²	\$2.00	\$3.21	
Cost per Mg	\$23.97	\$25.67	
Cost per km(2 lane)	\$14,600	\$41,400	

Slide	28
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Remixing Process City of Edmonton, Canada 1994

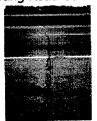
Slide 29

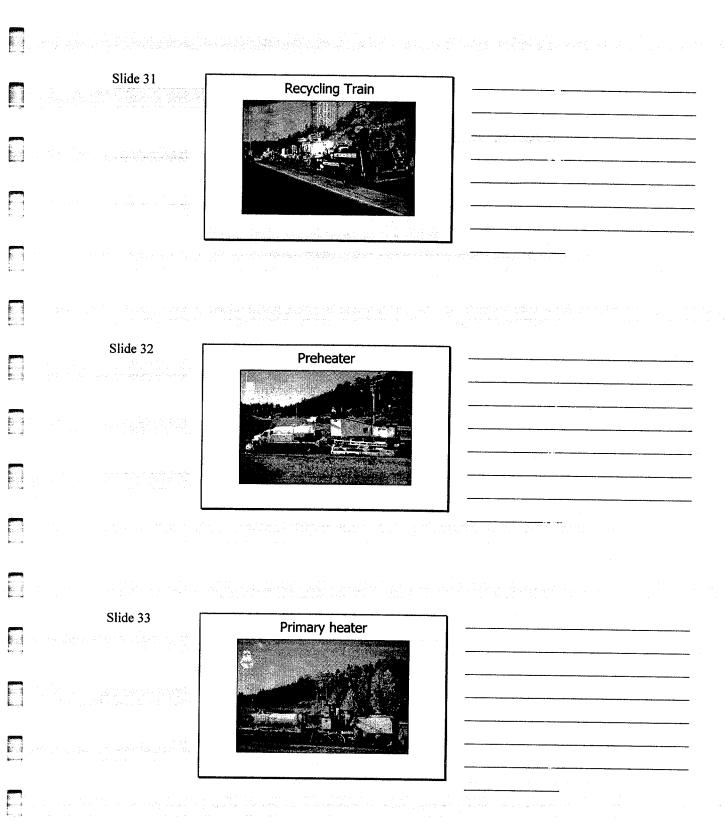
HIR

- HIR to a depth of 50 mm
- 0.15 0.20% recycling agent used
- 7% coated sand (2-3% asphalt content) mixed with existing HMA
- 75-Blow Marshall testing performed on recycled mix
- 137,600 sq. m of Recycling

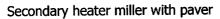
Slide 30

Existing Road Condition





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Road Before and After Recycling



Slide 36

Cost of Recycling

- Total Cost: \$ 262,701
- Cost per m²: \$ 5.01
- Estimated Cost of Conventional Technique:Remove and Replace:

\$ 6.60 -0 7.77 per m²

S	lide	37
- 73	nuc	

HIR

- Effectively used to treat rutting at intersections
- City of Edmonton, Canada
- Method used: Remixing

Slide 38

Intersection with rutting



Recycling train at intersection



SI	ide	40

Close-up View of Rutting at Intersection



View of Intersection After Recycling



Slide 42

Specifications for HIR

- Method specification
- End-result specification
- Combination of both recommended for HIR

Slide 43]
the line of the executive	Quality Control(QC)/	Quality Assurance (QA)	
	ITEM	METHOD	
	Depth of Scarification	Measure depth	
and the second of the second o	Application Rate of	Calculate from quantity	
	Recycling Agent	used	
		Determine asphalt content before and after	
		adding recycling agent	***************************************
	See Leading Control of Section 1998		
Slide 44			1
	QC/QA (0	Continued)	
	ITEM	METHOD	
	New Mixture Additio Rate	n Calculate from the Quantity Used	
	Temperature of Mix		
	Before Compaction	Measure	
	Properties of Asphalt	Recover Asphalt by ix Abson or Rotovap	
	bilider in Recycled M	Procedure and Test	
Slide 45	6114	1445)4	
	SUMI	MARY	
	■ HIR is Effective in Tre	eating Distress	
	■ HIR is Less Costly		
	į		
	■ Cause of Distress Sho Before HIR	uld be Ascertained	
	■ QC/QA Required		

Slide 46		
	Hot In-Place Recycling (HIR) Case Histories and QC/QA	
	???	

Slide 1		-
	Cold-Mix Asphalt Recycling	
	(Central Plant)	
	Construction Methods and	
र १५ क्षेत्र १५ कि.स.च्या स्थानसङ्ख्या । स्थानसङ्ख्या	Equipment	
.		
Slide 2	Cold Mix Recycling	
	■ RAP and Reclaimed Aggregate (if any) Mixed with New Asphalt Binder and New Aggregate (if Needed) to Produce Cold. Recycled Mix Without Application of Heat	
	■ Recycled Mix is Produced at a Central Plant Rather than In-Place.	
	a Capigua de para para especial de la companya de l	
Slide 3	Steps Involved	
	■ Removal of Existing Pavement	
and the second s	■ Crushing and Stockpiling	·
	■ Mixing	
	■ Laydown, Aeration and Compaction	

S	li	d	e	Δ

Steps Involved

- Removal of Existing Pavement
- Crushing and Stockpiling
- Mixing
- Laydown, Aeration and Compaction

Slide 5

Removal of Existing Pavement

- Rip Existing Pavement and Crush and Size at Central Plant
- Rip, Break and Pulverize on Site
- Cold Milling

Slide 6

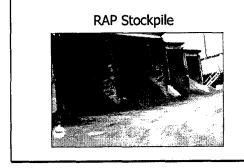
Ripping Process



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Slide 7	Milling with Truck Being Loaded with RAP	
		-
	ay maa ahtiyday eey mila ka dhiiday ka ah ka ka ka dhiiday ka ah	nggang sakarakan kanalas da
Slide 8	Steps Involved	
	■ Removal of Existing Pavement	
Secretaria de Companyo de la Companyo del Companyo de la Companyo del Companyo de la Companyo de	■ Crushing and Stockpiling	
	■ Mixing	
	■ Laydown, Aeration and Compaction	
La companya da sa		. And the second
Slide 9		
A CONTRACTOR OF THE SECOND	Important Considerations	
	■ Crush to Required Size	
	■ Do not Permit Construction Equipment on Stockpiles	

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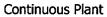
Steps Involved

- Removal of Existing Pavement
- Crushing and Stockpiling
- **■** Mixing
- Layaown, Aeration and Compaction

Slide 12

Mixing

- Batch, Drum, or Continuous (Stabilization) Plants Used
- Control Feed Rate of Cold Bins
- Plants should have capability to Add Water and Asphalt Binder
- Continuous Plants Most Common





Truck Being Loaded with Mix From Continuous Plant



Slide 15

Mixing

- Do not Overmix
- Do not Undermix
- 100 % Coating of Recycled Mix Not Always Possible

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	ide	. 16

Steps Involved

- Removal of Existing Pavement
- Crushing and Stockpiling
- **■** Mix...g
- Laydown, Aeration and Compaction

Slide 17





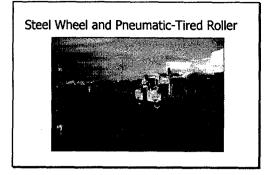
Slide 18

Laydown and Compaction



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	Slide 19 The second of the property of the second of the	Laydown and Compaction
1. 20.00		
	Slide 20	Aeration
		■ Required to Reduce Water and Volatile Content
B 4	and the state of t	■ Required to Support the Compaction Equipment
		■ Use Multiple Lifts if Curing is a Problem
The control of the co		
	Slide 21	Compaction
		■ Steel Wheel, Pneumatic-Tired or Vibratory Roller
4	and the second s	■ Use Heavy Weight, Pneumatic-Tired Roller for Breakdown
		■ Achieve Optimum Density ————————————————————————————————————

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Slide 24

Overlay

- HMA
- Double Surface Treatment
- Do not Place if Excessive Moisture in Cold Recycled Base
- Apply Fog Seal, if Necessary, before Opened to Traffic Prior to Overlay

Slide 25						
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Project with HMA Overlay



Slide 26

Summary

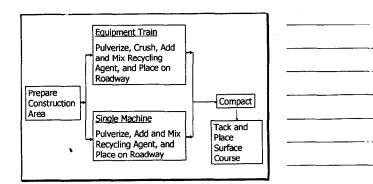
- Cold Mix Recycling can Rectify Reflection Cracking, Frictional Resistance, and Improve Ride Quality
- Procedure Involves Removal of Pavement Material, Crushing, Mixing and Laydown
- Aeration may be Required Before Compaction
- Wearing Surface Recommended

Slide 27

Cold-Mix Asphalt Recycling (Central Plant) Construction Methods and Equipment

???

Slide 1 Cold Mix Asphalt Recycling (In-Place) Construction Methods and Equipment Slide 2 Cold In-Place Recycling Existing Pavement Materials Removed, Mixed with Virgin Materials and Reused In Place	
Cold Mix Asphalt Recycling (In-Place) Construction Methods and Equipment Slide 2 Cold In-Place Recycling Existing Pavement Materials Removed, Mixed with Virgin Materials and Reused In Place	
Cold In-Place Recycling Existing Pavement Materials Removed, Mixed with Virgin Materials and Reused In Place	
Cold In-Place Recycling Existing Pavement Materials Removed, Mixed with Virgin Materials and Reused In Place	
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Cold In-Place Recycling Existing Pavement Materials Removed, Mixed with Virgin Materials and Reused In Place	
with Virgin Materials and Reused In Place	
Slide 3	
Cold In-Place Recycling Partial Depth Recycling Cold In-Place (50 to 100 mm) Recycling	
Full Depth Recycling Full Depth Reclamation	



Slide 5

Cold In-Place Recycling

- Single Machine
- Single-Pass Equipment Train

Slide 6

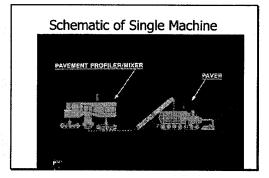
Cold In-Place Recycling

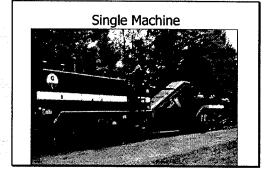
- **Single Machine**
- Single-Pass Equipment Train

Single Machine

- Milling Machine with Paver Mixer
- Breaks, Pulverizes, and Adds Recycling Agent in a Single Pass
- Virgin Aggregate, if Needed, Spread on Existing Surface
- Recycling Agent Added in Milling Chamber

Slide 8

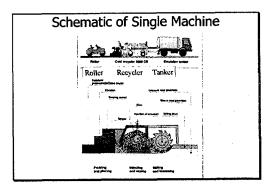


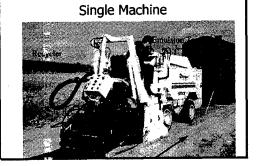


Single Machine

- Single Machine with Emulsion Tanker
- Single Machine Mills, Injects Emulsion, Mixes, and lays down with Screed
- Recycling Agent Added on Milled Material

Slide 11





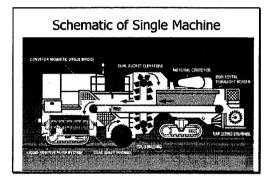
Single Machine

- Single Machine with Emulsion Tanker and Paver
- Single Machine Mills Existing pavement, Adds Recycling Agent, and Deposits Material in a Windrow

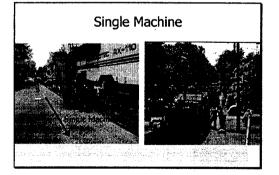
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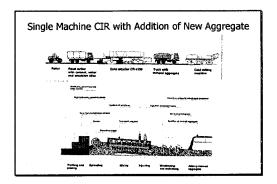
■ Paver Picks up Recycled Material and lays down with Screed

Slide 14

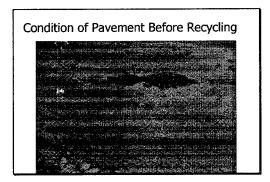


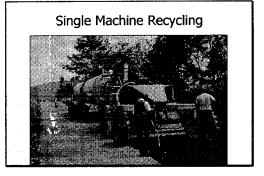
Slide 15





Slide 17





Slide 19]
	Condition of Pavement After Recycling	
The second secon		
	The state of the s	
Slide 20		-
Silue 20	Advantages	
	■ High Production	
	■ Simplicity	
to a thoronomic to the	Disadvantages	
	■ Depth Limitation	
in the second se	■ RAP Oversize	
en e	ing and the control of the control o	en de la companya de La companya de la companya del companya de la companya del companya de la c
Slide 21	4.000	٦
2	Cold to Disco December	
	Cold In-Place Recycling	

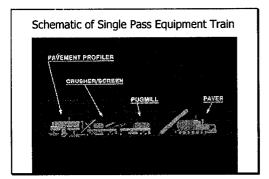
- Single Equipment Machine
- Single-Pass Equipment Train

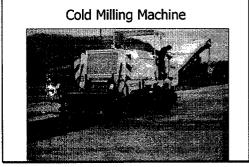
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Components of Train

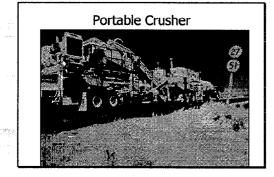
- Cold Milling Machine
- Portable Crusher
- Travel-Plant Mixer
- Laydown Machine

Slide 23

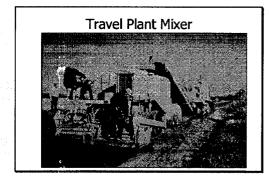




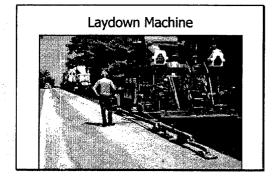




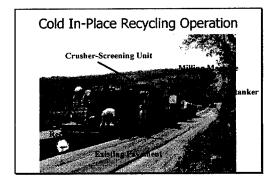
Slide 26



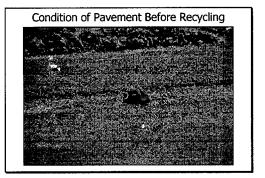
Slide 27



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Slide 32



Curing and Compaction

- Curing or Aeration Needed to Reduce Water and Volatiles
- Delay Rolling or Blade the Mix
- Use Steel-Wheel, Pneumatic-Tired or Vibratory Rollers; Use Heavy Pneumatic-Tired Roller for Breakdown
- Achieve Optimum Compaction

Application of Wearing Surface

- Additional Curing Needed to Avoid Moisture Retention
- Apply Fog Seal, if Necessary, Before Allowing Traffic
- Wearing Course: HMA Overlay or Double Surface Treatment

Slide 35





Slide 36

Summary

- Method can Eliminate Rutting, Cracking and Irregularities
- Can be Done by Single Machine or Equipment Train
- Mix May Require Aeration Before Compaction

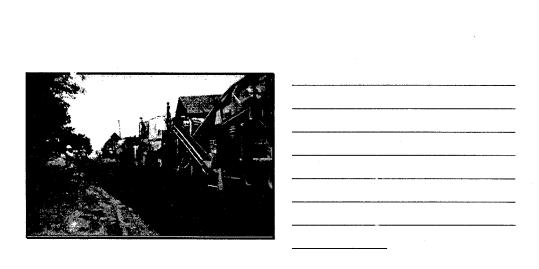
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la ca			emerika Pranjani, Projekti e e

Slide 1	Cold-Mix Asphalt Recycling	
	Case Histories and QC/QA	
	Akaragan di kacamatan 1919, Akamatan da bahar d Bahar da bahar da ba	and the second of the second o
Slide 2	Cold-Mix Asphalt Recycling Pulverization of Existing Pavement	
	■ Sizing of RAP, if Desired ■ Addition of Recycling Agent and Mixing	
je sa se	■ Placement and Compaction	
Slide 3		
The same and shape	Case History	
	Traffic Route 208 Mercer County Pennsylvania	
	1985	

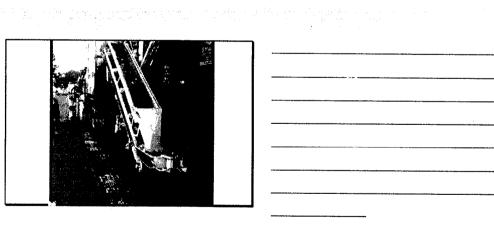
		•
Slide 4	Traffic Route 208	
	■ Traffic:	
	ADT: 2,500	
	Truck Traffic: 10 %	
Slide 5	Recycling Train	

■ Emulsion Tanker■ Milling Machine

■ Crusher■ Mixer■ Paver



Slide 7 Slide 8 Slide 9





Slide 11



Slide 12

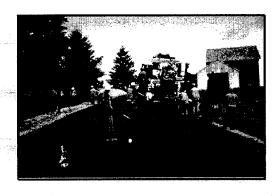
Recycling Process

- No Pre-Mix Water Used
- CS⊆ 1h Emulsion Diluted with 50% Water Used
- 3% CSS-1h by weight of RAP
- Vibratory and Pneumatic Tired Rollers Used
- 90 mm HMA Overlay over Recycled Base

Slide 13



Slide 14



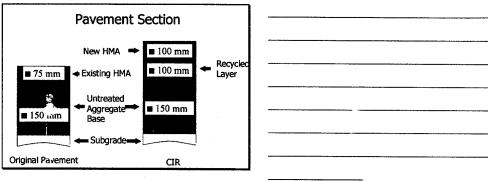
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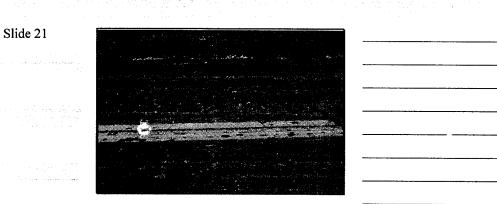


Slide 16		
Slide 17		
Slide 18	Case History	

Slide 19		
	US 64	
	■ Traffic:	
	AADT: 2,010	
anger kan de de lat ge	Average Daily Load (80kNESWL): 113	
and the state of t		

Slide 20 ■ 75 mm

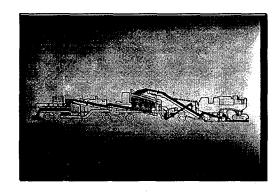




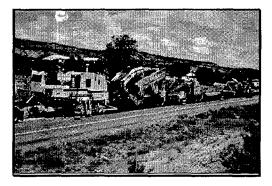


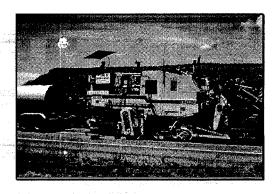


Slide 23



Slide 24

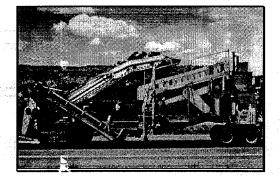




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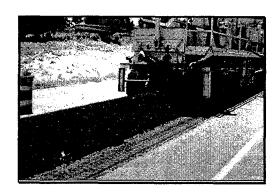
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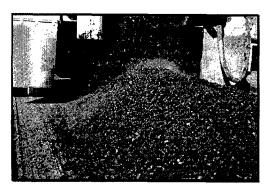
Slide 28



Slide 29



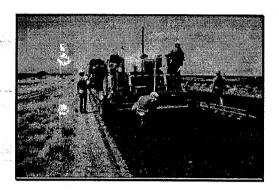
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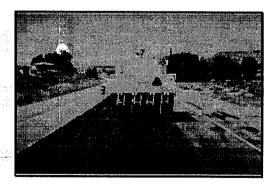


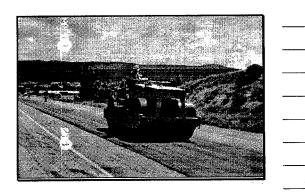
Recycling

- Polymer Modified High Float Emulsion Used at a Rate of 1-3 Percent
- Depth of Recycling: 100 mm
- 100 mm HMA Overlay Used

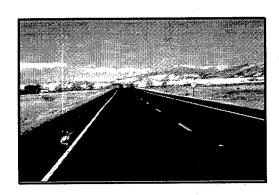
Slide 32



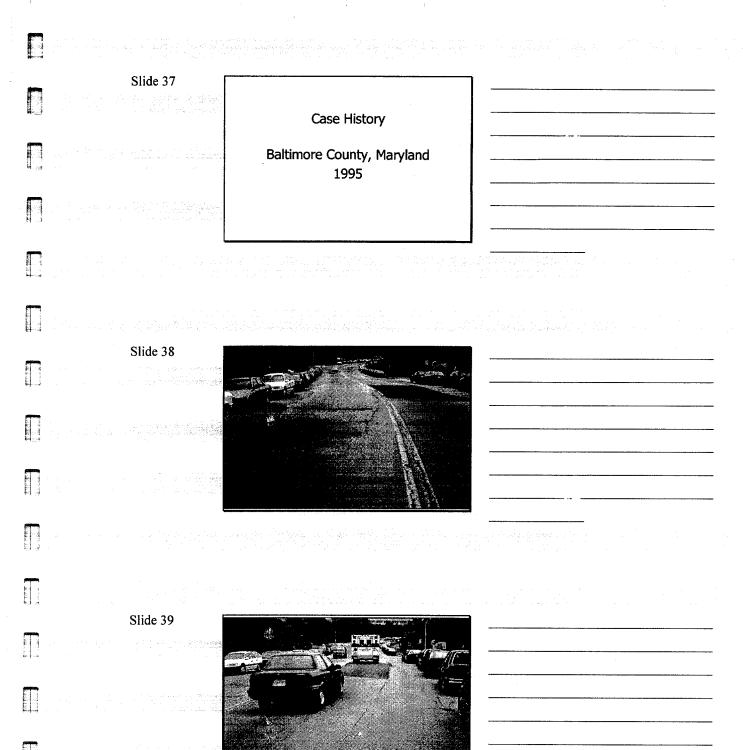




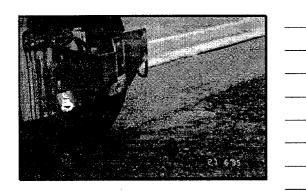
Slide 35



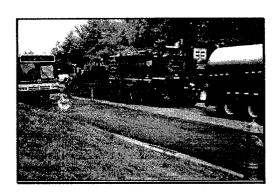
	Cost Cor	nparison	
Option	Initial Cost (per m²)	Maintenance Cost (per m²)	Total Cost (per m²)
CIR	\$5.75	\$0.13	\$5.88
Mill and Overlay	\$7.34	\$0.26	\$7.60
Cost Savings	\$1.90	\$0.13	\$2.03



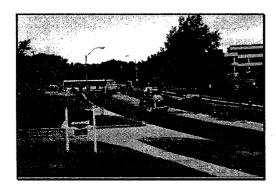
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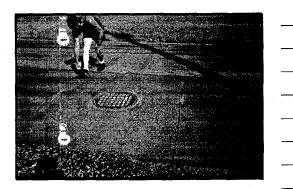
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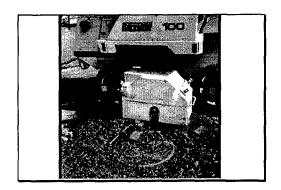
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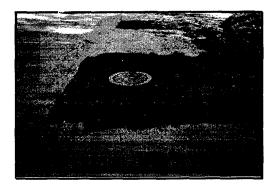


Slide 43	
	All Friends
	and the second process of the second process
Slide 44	
	PATER AND ASSESSMENT OF THE PATER ASSESSMENT O
Slide 45	
	Recycling Around Utility
	un deutsche Weiter als Archeitige Matter der Philipper und der Schallen in der Schallen der Schallen der Schal Gebeuten der Schalense Weiter der Schallen der Schallen der Schallen der Schallen der Schallen der Schallen de



Slide 47





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		Cold In-Place Recycling	
		■ Specification	
	na n	■ Quality Control/Quality Assurance (QC/QA)	
			and the control of th
		ngt Anghailigh if Mgasal a man jaranga ban	orași de Carrent de La Car La Carrent de La Carrent d
	Slide 50	Cold In-Place Recycling	
		■ Specification	
		■ Quality Control/Quality Assurance (QC/QA)	
	Slide 51	Specification	
		 Combination of Method and End Result Specification Recommended 	
	grande de la companya de la company La companya de la co	■ Emphasize End Result to Encourage Innovation in Equipment and Construction Procedures	
A Comment			

Slide 52		
	Commonly Specified Items	
	■ Depth of Pulverization ■ Maximum RAP size	
1 1 000	■ Specification for Recycling Agent	
	■ Specification for New Aggregate, if Used ■ Tolerance for Amount of Recycling Agent	
	■ Compacted Mat Density	
Slide 53]
	Cold In-Place Recycling	
	cold In Flace Recycling	
	■ Specification	
	■ Quality Control/Quality Assurance (QC/QA)	
		_
Slide 54	QC/QA Test Procedures	
	■ Depth of Pulverization	
	- Measure Against Unpulverized Pavement - Weigh pulverized Material from Known Area	
	■ Re-Mix Water	
	- Use Microwave Oven	

Recycling Agent ContentUse Extraction Method orUse Ignition Method

	Slide 55		1
		QC/QA Test Procedures (Continued)	
		■ Recycled Mix Gradation - Use Extraction Method or - Use Ignition Method	
Sede - voi		■ Compacted Mat Density - Use Nuclear Density Gauge	
		W of Theoretical Maximum Density or W of Laboratory Density or W of Control Strip Density	
	Slide 56		
	The property of Posts of Transference of the property of the	Summary	
П	· "一","一","一","一"的"一"的"一"的"一"。	 ■ Cold-Mix Recycling can Treat Cracks Effectively ■ In General, Emulsified Asphalt is Used as the Recycling Agent 	
	and the second of the second o	■ Double Seal Coat or HMA Overlay Recommended	
	and the second s	■ Important QC/QA Factors are Depth of Pulverization, Gradation of Material, Recycling Agent Content, and Compacted Density	
		udun ya dida Aryada Affin ya Aryada Marada Marada a Aryada a Marada a Arada	
	Slide 57		
17		Cold Mir Applied Description	
-		Cold-Mix Asphalt Recycling Case Histories and QC/QA	
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econoli,		???	
THE REAL PROPERTY.			

	Slide 1		
	en de la composition della com	Full Depth Reclamation Construction Methods	
		and Equipment	
	Slide 2	Definition	
STORY 9		Recycling Method Where <u>All</u> of Asphalt Pavement Section and a Predetermined Amount of Underlying Materials are Treated to Produce a Stabilized Base Course.	
		to Produce a Stabilized base Course.	
	er en		
			en de la companya de La companya de la co
	Slide 3	Advantages Pavement Structure (Especially Poor Base) Improved Without Significantly Affecting Pavement Geometry	
		■ Eliminates Ruts, Rough Areas, and Potholes and Restores Desired Profile	
		■ Elim:nates Alligator, Transverse, Longitudinal and Reflection Cracking	The Army of the management of the Control of the Co
		■ Provides a Uniform Pavement Structure	
		i. La figura de la capación de la capac	

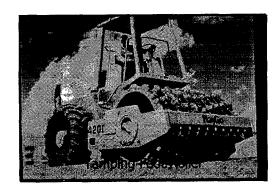
Slide 4		-
Slide 4	Advantages (continued)	
	■ Frost Susceptibility may be Improved	
	■ Low Production Cost	
	■ Conservation of Materials and Energy	
	■ No Air Quality Problems	
	a no var Quality Francis	
Slide 5		٦
	Main Steps	
	■ Pulverize Existing Pavement	
	■ Introduce Additive and Mix	
	■ Shape the Mixed Material	
	■ Compact	
	an Apply a Wearing Course	
Slide 6]
	Equipment	
	 Soil Stabilization Equipment and Different Variations of Oil Stabilization Equipment Are Used 	
	■ Blade Mixer	
	■ Motor Grader	
	■ Rotary Mixer	
	·	

Slide 7	In-Place Sizing and Mixing Operations	
e de la companya del companya de la companya del companya de la co	■ Multiple-Step Sequence	n en sego etako la masanten menerenden etakon beren eta
	■ Two-Step Sequence	
·	■ Single Machine	
	■ Single Pass Equipment Train	
	e de la companya de La companya de la co	
Slide 8	In-Place Sizing and	
	Mixing Operations	
	■ Multiple-Step Sequence	
	■ Two-Step Sequence	
	■ Single Machine	
	■ Single Pass Equipment Train	-
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	ing paggarang ang kalang paggan ng manggang manggang paggang ang ang ang manggang manggang manggang manggang m Tanggang manggang ma	ing the property and the control of the second of the control of t
Slide 9	Different Machines involved for	
	Different Operations	
	■ Ripping or Scarifying (Motor Grader or Dozer)	
The state of the same of the s	■ Size Reduction (Sheep Foot Roller or	
	Tamping Foot or Hammermill)	
	■ Mixing (Rotary Mixer)	
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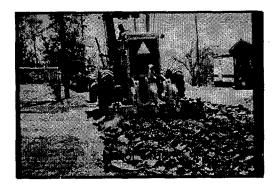
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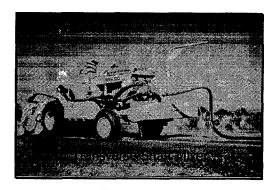


Slide 12





Slide 14



Slide 15



Slide	16	

Using Different Machines

- Advantage Equipment Readily Available
- Disadvantages
 Lack of Uniformity in Depth of Cut
 **ultiple Passes Required for Size
 Reduction
 Low Production Rate
 Traffic Control Problem

Slide	1	7
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In-Place Sizing and Mixing Operations

- Multiple-Step Sequence
- Two-Step Sequence
- Sin Machine
- Single Pass Equipment Train

Slide 18

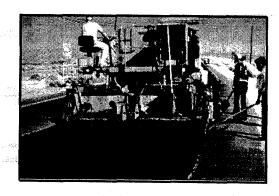
Two-Step Sequence

STEP 1 - Cold Milling Machine Used

STEP 2 - Soil Stabilization Mixing Equipment or Traveling Mixer Used for Adding and Mixing Recycling Agent

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Slide 21

In-Place Sizing and Mixing Operations

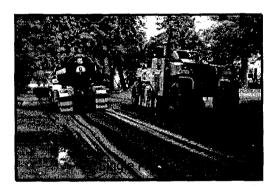
- Multiple-Step Sequence
- Two-Step Sequence
- Single Machine
- Single Pass Equipment Train

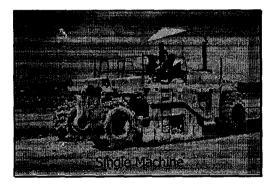
Single Machine

- Use ^ Cold Milling Machines which can Break, Pulverize, and Add Recycling Agent in a Single Pass
- Advantages:
 - High Production Rate
- Disadvantages:
 - Possibility of Aggregate Oversize
 Depth Limitation

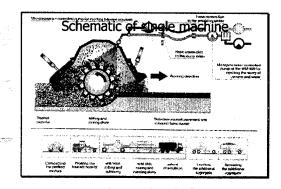
 - Necessity of Specialized Equipment

Slide 23





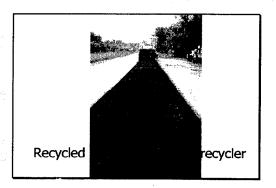
Slide 25



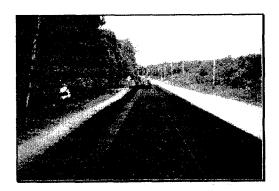
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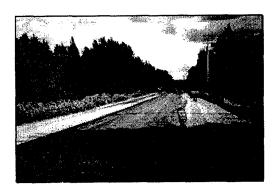


Slide 27



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Slide 30

In-Place Sizing and Mixing Operations

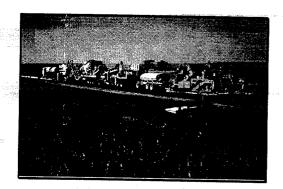
- Multiple-Step Sequence
- Two-Step Sequence
- m Single Machine
- Single Pass Equipment Train

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Single-Pass Equipment Train

- Uses a Set of Equipment Required for Milling, Pulverizing, Mixing and Laydown Operation
- Advantages:
 - High Production Rate
 - Partial Depth Removal of Asphalt Layer is
 Possible
 - No Oversize Material is Produced
- Disadvantage:
 - Specialized Equipment is Needed

Slide 32



- Common Recycling Additives
- Emulsified Asphalts (MS and SS)
- Portland Cement
- Lime
- Fly Ash
- Calcium Chloride
- **■** Foamed Asphalt

Curing or Aeration

- To Reduce Water/Volatiles and Support Roller Weight
- Co.: olled by Modifier Type, Water Content, Ambient Temperature, and Humidity

Slide 35

Compaction

- Static Steel-Wheel Roller
- Pneumatic-Tired Roller
- Vibratory Roller
- Combination of Rollers



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-	Slide 37		7
		Wearing Surface	
		■ HMA Overlay or Double Seal Treatment	
	en der de de de la segui estada en estad Estada en estada en	■ Detay until Mix is Cured - No Excessive Moisture	
		■ Apply Fog Seal, if Necessary, Before Opening to Traffic	
	Slide 38		
		Summary	
	garan kanang sawasan ng palipika katawas da da	■ FDR can Improve Pavement Structure, Restore Profile and Eliminate Cracks	
	The state of the s	 Steps Consist of Pulverization, Introduction of Additive, Shaping of Mixed Material and Compaction 	
		■ Proper Aeration of Mix Required	
	Slide 39		ר
		Full Depth Reclamation Construction Methods and Equipment	
		???	
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	Full Depth Reclamation Case Histories and QC/QA	
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Slide 2	Definition	
	Recycling method where <u>all</u> of asphalt payament section and a predetermined amount of underlying materials are treated to	
	produce a stabilized base course.	
Slide 3	Case History	
	Mt. Wachusett Road Princeton, Massachusetts 1991	

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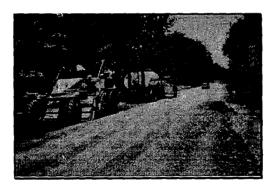
Mt. Wachusett Road, Princeton, Massachusetts

- Existing pavement 75 mm HMA over 150 mm macadam base (badly potholed)
- Full depth reclamation to a depth of 150 mm
- Liquid calcium chloride used as additive
- Overlay: 50 mm HMA binder course and 32 mm HMA wearing course

Slide 5

Mt. Wachusett Road, Princeton, Massachusetts

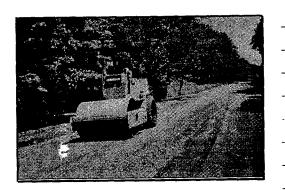
- Road reclaimer used to pulverize (150 mm depth)
- Calcium chloride applied by a tanker spray bar (3.5 l/m²)
- Material Pulverized second time to mix calcium chloride
- Grader used to shape the mixed material
- Vibratory roller used to compact reclaimed base



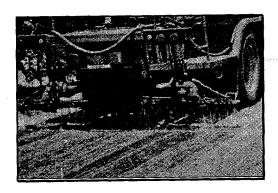
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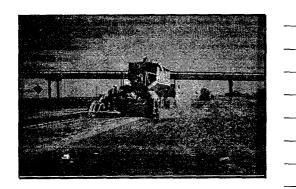


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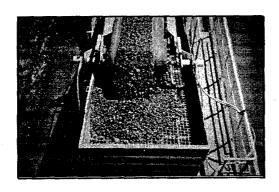


Slide 13		<u> </u>
	Case History	
	I-40, Amarillo, Texas	
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	and the second	
		en de la companya de La companya de la co
Slide 14		
Silde 14		
	I-40, Amarillo, Texas	
	■ Existing pavement had cracks	
atti ili ja	■ Full depth reclamation of 178 mm of HMA and 76 mm of existing base	
	 Existing material milled, pulverized, screened, and treated with cement and water to 	
The second secon	produce cement treated base	
and the second of the second o	■ MC-20 cutback asphalt used to prime surface	
ļ	Approximately the second and the sec	•
	international designation of the second of t	
Slide 15		

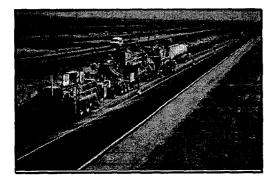
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Slide 17



Slide 18



Slide 22	Case History Mendota, California 1997	
Slide 23		

Sinde 23

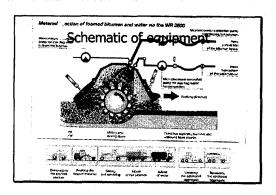
Slide 24

Small

Material

Existing Road Sti

Slide 25



Slide 26



Slide 27



Slide	28
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Slide 29



Slide 30



	Slide 31	Full Depth Reclamation	
e out	e i filozofi e filozofi e jakolfysweg ské filozofi	i un Deput Reciamation	
		■ Specification	
		■ Quality Control/Quality Assurance (QC/QA)	
	en de la companya de La companya de la co	en de la companya de La companya de la companya del companya de la companya de la companya del companya de la companya del la companya del la companya de la companya de l	
		i kan kalengelok kepujatan kalengan dan dalah beraik da terbis di kebesalik da mengalah dalah bilangan da dengan pada basah bilan dan dibi	
	Slide 32	Full Depth Reclamation	
		■ Specification	
		■ Quality Control/Quality Assurance (QC/QA)	
	Landing to the second s	ark og en ekste skrygg flerhej grup et sterren en en arter blev blev og eksterren. Sterren en en en og består en	
	en gyana katalog eta eta eta gapeantea (erijaljus galanikoj lietika vikus vikus ir jihtus lu
	Slide 33		
51 9		Specification	
	The second secon	Combination of Method and End Result Specification Recommended	
4		■ Emphasize End Result to Encourage Innovation in Equipment and Construction Procedures	
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Commonly Specified Items

- Depth of Pulverization
- Maximum RAP size
- Specification for Recycling Agent
- Specification for New Aggregate, if Used
- Tolerance for Amount of Recycling Agent
- Roller Weight and Sequence
- Compacted Mat Density

Slide 35

Typical Specification

- 97 % of Pulverized Material Should Pass 50 Mm Sieve
- Compaction Should Be With Rubber Tired Roller Followed by Vibratory Steel Wheel Roller
- Minimum Weight of Rubber Tired Roller and Vibratory Roller Are 22.7 Mg and 7.3 Mg Respectively

Slide 36

Full Depth Reclamation

- Specification
- Quality Control/Quality Assurance (QC/QA)

Slide 37		7
	QC/QA Test Procedures	
	 ■ Depth of Pulverization - Measure Against Unpulverized Pavement - Weigh Pulverized Material from Known Area 	
	■ Re-Mix Water - Use Microwave Oven ■ Recycling Agent Content - Use Extraction Method or - Use Ignition Method	
		adentikan di kasul sulah di mendilan di kecamatan di kecamatan di kecamatan di kecamatan di kecamatan di kecam Kanan di di kecamatan di kecamat
Slide 38		-i
	QC/QA Test Procedures (Continued)	
	Recycled Mix Gradation - Use Extraction Method or - Use Ignition Method	
	■ Compacted Mat Density - Use Nuclear Density Gauge - % of Theoretical Maximum Density or - \$. Jf Laboratory Density or - % of Control Strip Density	
	gen and the constitution of the constitution o	
Slide 39		
	Summary	
	■ FDR can be Used Successfully Without Major Traffic Flow Interruption	
	 QC/QA Factors Include Aggregate Gradation, Stabilizer Content, Water Content, and Compacted Mat Density 	
al estimates		

Slide 40	Full Depth Reclamation Case Histories	
	and QC/QA	and the second section of the second
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